SAM Configuration Manual

Ordering Number: 9032 011 987

Issue November 14, 2000

This version replaces all previous versions of this document. It also replaces the SAM System User's Manual (1997). Inmotion Technologies and ACC Motion have made every effort to insure this document is complete and accurate at the time of printing. In accordance with our policy of continuing product improvement, all data in this document is subject to change or correction without prior notice.

ACC Motion SA
Zone industrielle La Rippe
CH-1303 Penthaz
Switzerland

P/n 9032 011 987
Issue November 14, 2000

Table of Contents

List of Figures

List of Tables

Introduction

Scope of this Manual

This SAM Configuration Manual presents procedures and guidelines for start-up of a SAM Drive in a PAM and SAM environment.

Related Documents

The PAM and SAM System User's Handbook (in 6 parts) documents the Hardware. This SAM Configuration Manual contains information related to Software.

Intended Use of SAM Products

The SAM product line constitutes a Power Drive System according to international standard IEC 611803, and Power Conversion Equipment according to UL standard 508C. Its intended use is for powering and controlling moving parts within industrial machines. SAM products are supplied as subassemblies to professional assemblers for incorporation into machines, apparatuses or systems. Assemblers are responsible for insuring that the SAM products are used for their intended purpose only, and for compliance with all applicable regulations.

According to the European Directive 80/392/EEC regarding machinery, putting a SAM Power Drive System into service is prohibited until the machinery into which it is to be incorporated has been declared in conformity with the provisions of this Directive.

Personal Safety

The SAM product line is intended for connection to standard main voltages up to 480 VAC and for running motors up to 8000 rpm. High voltage and moving parts can cause severe or fatal injury. ACC Motion and Inmotion Technologies provide this and other manuals for assisting assemblers in using the products in a correct, efficient and safe manner.

Assemblers must insure that all persons responsible for design, test, maintenance and use of SAM have the proper professional skill and apparatus knowledge.

For compliance with the EC Directives and standards applicable to SAM products assemblers must read, understand and apply the specified procedures and practices regarding safety set forth in the PAM and SAM System User's Manual (6 parts).

When modifying PAM and SAM System Software, parameters, variables or any other configuration setting, the user must keep in mind that motors are powerful enough for causing fatal injuries to humans, and severe damage to machines.

Warnings, Cautions and Information Notices

Special attention must be paid to the information presented in Warning, Caution and Information notices when they appear in this manual. Examples of these notices along with a description of their purposes follow:

An Information Box contains supplemental information or references to supplemental information on a topic.

The Stop Box highlights important conceptual or procedural details that must be understood and applied in order to successfully use the product.

A Warning informs the user of a hazard or potential hazard that could result in serious or fatal injury if the precaution or instruction given in the Warning notice is not observed.

SAM Tools

Preliminary Remark

All software components that are required for running a PAM and SAM System are supplied on the "ProMotion Collection" CD-rom. Each collection gathers several versions, together with several utilities and documentation.

The ProMotion Help file provides also for comprehensive information about SAM Tools.

Installing SAM Tools

PC Hardware Platform

Minimum PC Configuration Required

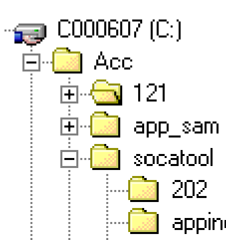
- 80486 processor
- 8 MB RAM memory
- 16 color VGA graphic adapter
- 1 serial port
- 15 MB disk space (for SAM Tools only), 30 MB for complete Promotion package
- Windows 95 or 98 installed

Recommended PC Configuration

- Pentium processor
- 16 MB RAM memory
- 16 color SVGA graphic adapter
- 1 serial port
- 15 MB disk space (for SAM Tools only), 30 MB for complete Promotion package
- Windows 95 or 98 installed

Installation for multi-version use

The hierarchical structure proposed to be able to have different PAM & SAM systems and 32 bits new applications installed on a single PC is described in Figure 1. It is sharply recommended to use this structure to get the best efficiency.



Struct2.bmp

Figure 1 Multi-version structure

How to migrate from an old structure to the new structure

If your previous installation does not correspond to this structure, proceed as follow:

1) Quit the installation program.
2) Launch File Manager.
3) Remove all old versions of ProMotion on the PC.
4) Edit AUTOEXEC.BAT file and **remove** the following lines:

- SET PAM=C: \SOCATOOL
- SET PAMAGL=.
- SET PAMSRCE=..\SRCE
- SET PAMTEMP=C:\SOCATOOL\TEMP
- SET PATH=xxx;C:\SOCATOOL (remove only the path to SOCATOOL)

5) Reboot the PC.
6) Restart the Master Setup.

During installation, a name for the root directory is requested. It **must be as short as possible** to guarantee that the old versions are running properly. By default, this directory name is “ACC”. Longer directory name should not be used.

How to install a ProMotion version

1) From the CD-Rom and Master Setup, choose the desired ProMotion version and follow the instructions.
2) From the CD-Rom without the Master Setup, explore the CD-ROM, choose the desired ProMotion version, open the directory called Disk1 and launch the application SETUP.EXE

How to install a Service-Pack

A Service-Pack is an upgrade of a ProMotion version. It is designed for only one version of ProMotion.

Proceed like a ProMotion installation. Be sure that you install the corresponding Service-Pack.

How to install several ProMotion versions

1) If any ProMotion version is already installed with the new structure, rename the “SOCATOOL” directory (with file manager) with an explicit name (i.e. V121 for ProMotion version 121).
2) Install the new ProMotion version as usually.
3) To use older PAM & SAM systems, it is enough to rename the directory «SOCATOOL» like above and to rename the selected directory in «SOCATOOL»

How to install a Service-Pack on a structure with several ProMotion versions

Verify that the corresponding ProMotion version is installed and activated (The directory SOCATOOL corresponds to the selected ProMotion version)

Setting up the COM Port

When SAM Tools is installed, COM1 port of the Service PC is selected by default. To select COM port 2 perform the following:

For Windows 95 and 98:

1) Access SAM Tools, properties
2) Select shortcuts tab
3) Under target add “COM2” separated by a space
(i.e. xxxx\SAM TOOLS.EXE COM2).

Getting Started with SAM Tools

Top Level Window

Status and Display Components

Figure 2 shows the SAM Tools top level Window with the status and display components identified. Table 1 provides a description of these components.

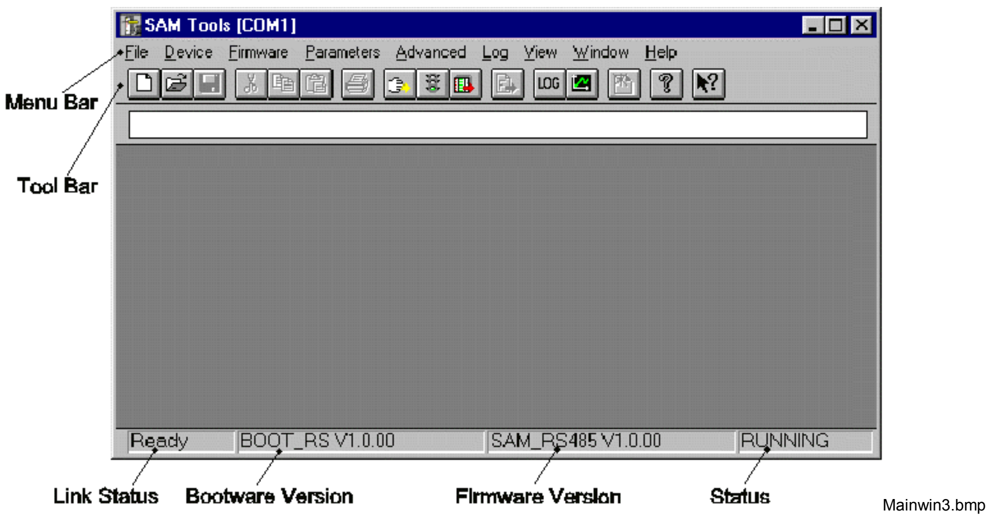


Figure 2 SAM Tools Top Level Window

component	description
link status display	Displays status of SAM - Service PC communications link at time of last handshake
Bootware Version display	Bootware version residing in SAM Drive
Firmware version display	Firmware version residing in SAM Drive
SAM Drive status display	Displays current SAM Drive operating state
log message display	Most recent log message from SAM Drive
menu bar	Contains SAM Tools main pop-down menus
tool bar	Contains buttons for activating SAM Tool functions. Buttons for active functions appear in high contrast, colors on non-active buttons are subdued

Table 1 Description of Components of SAM Tools Main Window Components

Tool Bar

When the mouse cursor is placed on an icon, a brief description of the buttons is displayed in a box.

SAM Tools Subdirectories and File Extensions

During installation SAM Tools creates a number of subdirectories at the directory specified by the user at the beginning of the installation procedure. Different types of files as described in Table 2 are deposited into each of the subdirectories. ACC recommends retaining this structure as well as the file extension defined for each file type because software upgrades and revisions rely on this file structure.

sub directory name	ext.	description
firmware	.sfi	SAM Drive firmware files
bootware	.sbi	SAM Drive bootware files
params	.spa	SAM Drive and motor parameter files
panels	.pan	Creation files for ACC standard panels
cmds	.stc	ACC standard trace commands files
	.shc	host commands files (up to version 1.3)
support		conversion utility and C++ example programs
symbols	.syd	symbols dictionary
help		on-line help files
temp		temporary workspace for files created during SAM Tools execution

Table 2 SAM Tools Subdirectory and file extension conventions

We recommend that users create separate directories utilizing the same subdirectory and file extension structure for storing and archiving user-created parameter, panel and trace files.

Parameters

SAM Tools provides the capability to download parameter files to a SAM Drive and upload parameters from a SAM drive into a file on the Service PC. The parameter upload and download features provide the means for recording, saving and replicating axis (software) configurations.

Downloading Parameters

Parameters are downloaded into SAM Drive RAM memory where they remain until changed by command from a host PC/PLC or SAM Tools via the service port. Upon resetting the SAM Drive or upon power-up all parameters are initialized to values saved in flash memory.

Upon receipt of a “save parameters” command, the drive firmware copies an image of all parameters from RAM into flash memory. Parameter value changes are immediately accessible to the drive firmware; however, the firmware uses certain parameters only during initialization.

To be saved, parameters have to be copied into the flash memory using the “SAVE” command in the “Parameters” menu. Doing that, **existing parameter values are overwritten and lost**.

Existing SAM Drive parameter values may be preserved by uploading them to the service PC prior to downloading new parameters..

Motor Parameters

Motor parameters must be downloaded to properly configure a SAM Drive for the motor it is controlling. To insure that a SAM Drive is properly configured for the motor it is controlling, this procedure should be performed whenever a SAM Drive is installed in a SAM system or whenever existing motor parameters are invalid or suspect.

When downloading motor parameters, be certain to select the correct file for the motor model connected to the SAM Drive.

Downloading incorrect motor parameters may cause unpredictable motor or drive behavior, and possibly be harmful to the drive or motor.

Application related Parameters

Some parameters related to the application (position controller parameters, etc.) have to be tuned to obtain the best performances of the system. Refer to SAM Drive Tuning Procedure on page 42 for tuning procedure.

Uploading Parameters

SAM Drive configurations (parameter sets) may be uploaded to a Service PC for viewing, editing, saving or other purposes using SAM Tools. During an upload, the complete set of parameters in RAM is uploaded. The uploaded parameter set when downloaded to an identical (same model) SAM Drive configures the drive exactly the same as the SAM Drive from which the parameter set was extracted.

The parameter values currently in RAM are uploaded to the Service PC where they are saved in the PARAMS subdirectory. SAM Tools assigns the filename "PARAMxxx.SPA where xxx is incremented by one each time SAM Tools saves a parameter set. The user may rename and relocate uploaded parameter sets using the standard SAVE AS... Windows file commands from the FILE menu.

Two types of parameter upload procedure are available; a standard upload and an "Upload with Template. In the "Upload with Template" operation, a user-created template attached to the parameter file controls which parameters are uploaded and which are not. Some pre-defined templates are available in ProMotion (see Table 3).

file name	upload
allvvxx.spa	all parameters in alphabetical order
appvvxx.spa	all parameters except drive specific ones

Table 3 ACC Standard Upload Templates
(vv = version number, i.e. all20xx.spa for version 2.0)

Upgrading Boot/Firmware

The following procedure is for upgrading bootware and firmware of SAM Drive (see Initialization on page 30 for definitions of bootware and firmware).

1) Upload parameters with template App15XX.SPA.
2) Save parameters as contextual name (e.g. Axis3.spa).
3) Stop the SAM.
4) Download the new bootware (SBEZxxxx.sbi).
5) Download the new firmware (SFEZxxxx.sfi)
6) Download saved parameters with contextual name.
7) Save all parameters.
8) Start the SAM.

If a 24 VDC supply failure occurs during wring of the bootware program into flash memory, the SAM Drive will become inoperative, requiring **factory repair**. Therefore, we recommend this procedure be performed only when absolutely required.

Upgrading bootware and firmware from System version 1.2_xx or older requires a special procedure. Refer to Promotion.hlp help file for more information.

Replacing a SAM drive

To be able to change a SAM drive in good conditions, it is recommended to have a saved parameters file of each axis. To create such a file, the following procedure is used.

1) Upload parameters with template App20XX.SPA.
2) Save parameters as contextual name (e.g. Axis3.spa).

Then its is very simple to change a SAM drive. Proceed as described in the “PAM and SAM System End-User’s Manual”.

i

If parameters are managed within the PAM application, this procedure is not necessary.

i

When replacing simultaneously the SAM software version, more information is available in ProMotion Help “How to install a new SAM System” topic”.

Control Panels

Overview

A particularly powerful and useful feature of SAM Tools is the capability to create custom control panels on the Service PC monitor. Control panels provide direct, simplified access to a SAM Drive via the service port for tasks such as testing, monitoring or servicing an axis. Panels may be customized to the extent that buttons and displays have customized legends relevant to the machine or application or language of the country where used. Control panel attributes are stored in software files permitting control panels to be stored, recalled and recreated as needed.

A control panel is a customizable graphical interface to the SAM Drive, which provides the capability to interrogate and manipulate SAM parameters and fields. SAM Tools software provides the interface between a control panel and a SAM Drive, converting operator and actions to the appropriate commands and updating the panel based on the drive’s responses.

ACC Standard Control Panels

ProMotion includes a library of standard panels useful for various aspects of SAM system monitoring, tuning and control. A description of the ACC standard panels is found in Table 4. These standard panels may also be used as the starting point for a user creating customized panels for a specific application.

file name	used to
analog.pan	define which variables to convert in analog outputs on Test Device
brake.pan	check brake behavior
endat.pan	display EnDat features of multiturn encoders and resolvers
hardinfo.pan	display hardware information
init_loc	check and initialize local position
init_mon	check and initialize 2nd position feedback
init_pol.pan	check linear and some direct drive motors (System 2.0 and up)
io.pan	check and configure I/Os
magnali.pan	check linear and some direct drive motors (System 1.3 and 1.5)
main.pan	check general behavior
mask.pan	define Status Masks
mot_enco.pan	special panel for motors fitted with an sine-cosine encoder
motor.pan	view (and modify) motor parameters
move.pan	define and run repetitive movements on motor (System 1.3 and 1.5)
msampler.pan	check SAM interface to PAM-emitted position trajectory
regcur.pan	check Current Controller parameters
regsamp.pan	display fast input sampling
resolver.pan	check resolver and motor wiring and setting
sap_all.pan	display all SAM application variables
sensor.pan	display and define all feedback settings
stat_ab.pan	display Status A and B
stat_cd.pan	display Status C and D
st_com.pan	display EasyBus communication status
st_enco.pan	display Sine-Cosine encoder status
st_main.pan	display Main Status (status_m.pan on 1.3; statmain.pan on 1.5)
st_mes.pan	display internal resolver status (statmes.pan on Syst. 1.3 and 1.5)
status.pan	display all status fields
t_device.pan	define which variables to convert in analog outputs on Test Device
temper.pan	display temperatures and voltages
torq.pan	display and define SAM in Torque mode
tst_move.pan	define and run repetitive movements on motor (Syst. 2.0 and up)
tuning.pan	check and adjust Position Controller parameters
z_mark.pan	display reference mark of encoders

Table 4 ACC Standard Panels (not available in all software versions; refer to \ACC\Socatool\Panels sub-directory content.)

Control Panel Components and their Operation

This section describes the components of a control panel and their operation. Figure 3 illustrates a sample control panel containing each of the available control panel component types with each component type labeled. Each of the panel component types is described in the following paragraphs.

General Instructions for Control Panel Dialog Boxes

For most types of dialog boxes, SAM Tools places a border around the box when it has been opened and no other operations are allowed until the box is closed. The border color is red initially and changes to blue when the value is changed. Once the content of a box has been changed, press the ENTER key to update the corresponding SAM Drive parameter/field, or press ESC (the ESCAPE key) to restore the original value and exit the box.

In order to display the current value of SAM Drive fields/parameters a control panel must be updated. Control panels are automatically updated when initially opened and when reactivated. A user may update a control panel at any time by pressing the **REFRESH PANEL** button on the SAM Tools toolbar.

STOP

In order to display the current value of fields and parameters, a control panel must be updated. Control panels are automatically updated when initally opened and when re-activated. A user may update a control panel at any time by pressing the **REFRESH PANEL** button on the SAM Tools tollbar.

Numeric Entry Box - This type of box accepts numeric values. To change the value, click inside the box, then modify the existing value or enter a new value. The units of numeric entry boxes are the units of their corresponding fields in the SAM Drive. The units are generally included in the box label.

Numeric values are displayed in decimal, hexadecimal and scientific format. The format used is a function of the corresponding field and panel setup.

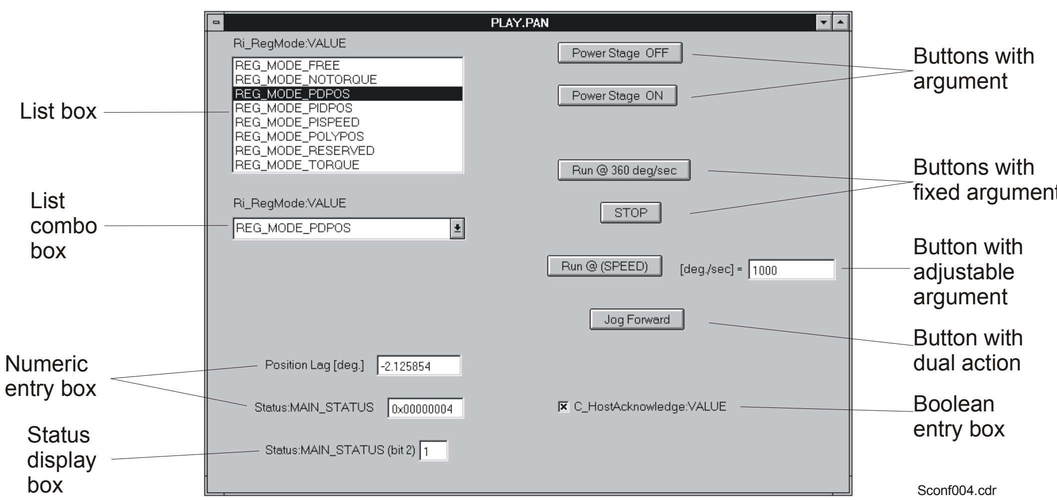


Figure 3 Control Panel with Component types Identified

Status Display Box - These are single bit, read-only boxes used for displaying the value of a single SAM Status bit.

Boolean Entry Box - This type of box is used for controlling the state of Boolean inputs, which can only be true or false. An “x” in the check box means the input is in it’s true state, and a blank check box means the input is in it’s false state.

List Box - The value of the corresponding field/parameter highlighted in a contrasting color. Select an item from the drop-down list displayed in the box changes the value; then press ENTER on the keyboard.

List Combo Box - Displays a pop-down list of selections.

Button - Clicking on a button initiates one or more specific, pre-programmed actions. A button may operate in any of several ways depending on how it is specified in the control panel. The possibilities (see Figure 3) include buttons having no argument, buttons with fixed arguments (built into the button specification), buttons with an adjustable argument whose value is taken from a numeric entry box, and dual action buttons which produce an action when depressed and an action when released.

Activating a Control Panel

Opening its file from the SAM Tools Log window activates a control panel. To open a control panel file, perform the following steps:

1) From the FILE menu select OPEN,
2) In the "File Open" dialog box, select the file name (including path) of the control panel to be activated, then press OK. All control panels have the file extension ".PAN".

If the desired control panel is listed on the SAM Tools recall list, it may be accessed as follows:

1) From the FILE menu, select RECALL, then select PANELS from the submenu.
2) From the pop-down list, select the desired panel.

More than one control panel may be open at a time, but only one panel may be active and only the active panel is responsive. The user may change the active panel by clicking in the panel to be activated.

The display boxes on a panel are updated automatically when the panel is opened or activated.

Creating a New Control Panel

Creating a new control panel is a straightforward process, which requires performing the following steps:

1) Determine the functions required of the panel
2) Open a new panel document
3) Create buttons, displays and numeric entry boxes and specify their operation
4) Add any custom labeling or nomenclature desired.

Determine the Functions Required

Panels are usually created for performing a specific task and include only those controls required for the task. This approach simplifies creation and use of the panel. The ProMotion Help, "SAM Parameters & Fields" topic provides a listing and description of all SAM Drive fields and parameters accessible by panel.

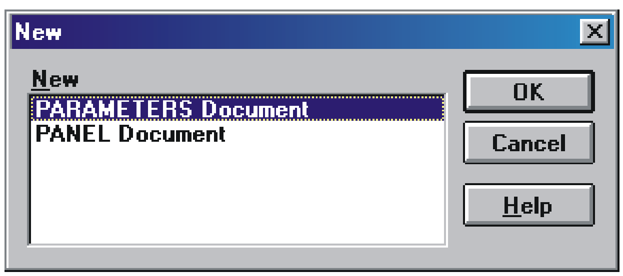
Although functions to stop motion and disable a SAM Drive output may be included on a panel, these functions cannot be considered “safe” as defined in IEC 60204-1 or IEC 61803. Safety functions must be implemented as specified in the PAM and SAM System User’s Handbook, Part 3 – Safety and Protective Functions.

Opening a New Panel Document

1) From the SAM Tools Log window, select FILE then NEW.
2) In the “NEW” dialog box (see Figure 4) select **PANEL DOCUMENT**. A new window containing a blank panel is opened.
3) To assign a file name to the panel file, select FILE then SAVE AS. In the “FILE SAVE AS” dialog box, enter a file name and select a path.

STOP

When a new panel document is created, the panel window is opened in “Edit Mode”, which is the correct mode for creating and modifying panels. When utilizing a panel window as a control panel, the panel must be in “Execute Mode”.



Sconf011.cdr

Figure 4 New Dialog Box

Creating Control Panel Components

Creating control panel components is a menu driven process in which buttons and boxes are created by selecting from a list of parameters, fields and methods accessible from control panels.

The nature of a field/parameter selected dictates the type(s) of entry or display box created. For buttons, the selected method dictates the button type(s) created.

Creating Entry and Display Boxes

To create an entry or display box in an open Panel document, perform the following steps:

1) If the panel is not in “Edit Mode”, select EDIT from the PANEL menu.
2) Select NEW CONTROL from the PANEL menu.
3) Using the Object Browser, locate and select the field or parameter to insert into the control panel. Press OK.
4) In the “Choose Control Type” list box select a display box

Trace

One of the most useful features of SAM Tools is its trace capability. The behavior of up to up to four SAM variables as a function of time may be captured, displayed, printed or saved for reference purposes. Trace setup information including trigger point specifications, sampling rate and trace variables are defined in a Trace Command file created using SAM Tools. Trace data is captured and saved in a reserved segment of SAM RAM memory, then uploaded on command to the Service PC where it may be displayed or saved and displayed at a later time.

The trace trigger point is defined by an expression, which may be a combination of numerical and logical values and operators. As with most digital storage oscilloscopes, the trace tool may be configured to display data before and after the trigger point. The sampling rate is adjustable over a wide range of values from processor cycle rate (8 kHz) to 1 (one) Hz.

ACC Standard Trace Setups

The ProMotion includes a number of standard Trace command files for creating the Trace setups referenced in this manual. A description of these ACC standard trace setups in found in Table 5. These standard traces may also be used as the starting point for users creating custom traces for specific applications.

file name	description
marker.stc	trace SAM application markers
regcur.stc	current regulation
regpos.stc	used with tuning.pan to adjust feed-forward components of the Position Controller
resolver.stc	display resolver signals
resshift.stc	display resolver interface voltages
setpoint.stc	display set point from PAM
speed.stc	display speed reference
st_ab.stc	display status AB
st_cd.stc	display status CD
tetapos.stc	display measured position and polar angle
timing.stc	display internal SAM tasks duration
tmagn20.stc	display polar angle teach-in sequence
trace_io.stc	display inputs
tuning.stc	used with tuning.pan to adjust gains of the Position Controller

Table 5 List of ACC Standard Traces

Producing a Trace

This paragraph describes the procedure for setting up a Trace using an existing Trace Command file:

1) From the Log window's DEVICE menu select TRACE COMMANDS.

2) In the "Trace Commands" dialog box (see Figure 5) press LOAD. In the "Open" dialog box, select the subdirectory containing the trace commands file to be utilized. Trace Command files have the file extension ".STC". Click OK.

3) The selected trace command file (see Figure 5) is now displayed in the “Trace Commands” dialog box. It defines for each channel, the label and the type, the address and the size of the variable to display. Table 6 shows the type and the size of the most interesting variables to trace. For addresses, as they are related to the firmware version, please use the browser for the DSP variables or refer to the “ProMotion.hlp” help file for the i960 variable. A “Trace” control panel (see Figure 6) is also displayed.

4) In the “Trace Commands” dialog box press EXECUTE to setup the SAM Drive for capturing the trace data. The message “Execution Successful” appearing in the “Trace Commands” dialog box indicates successful setup of the SAM Drive.

5) Press CLOSE to close the “Trace Commands dialog box.

6) In the “Trace” control panel, press START to initiate the trigger.

7) When the Trace control panel displays **TRIGGERED** and **STOPPED** the trace data gathering operation is complete. On the “Trace” control panel press UPLOAD to upload the trace data to the Service PC for display. The trace data is also saved to a file in the TEMP subdirectory. SAM Tools assigns the name “TRACExxx.TRC (where xxx is the next number in sequence) to the trace file.

8) To initiate another trace operation utilizing the same trace setup, first press  on the SAM Tools toolbar to recall the “Trace” control panel, then press START to initiate another trace operation.

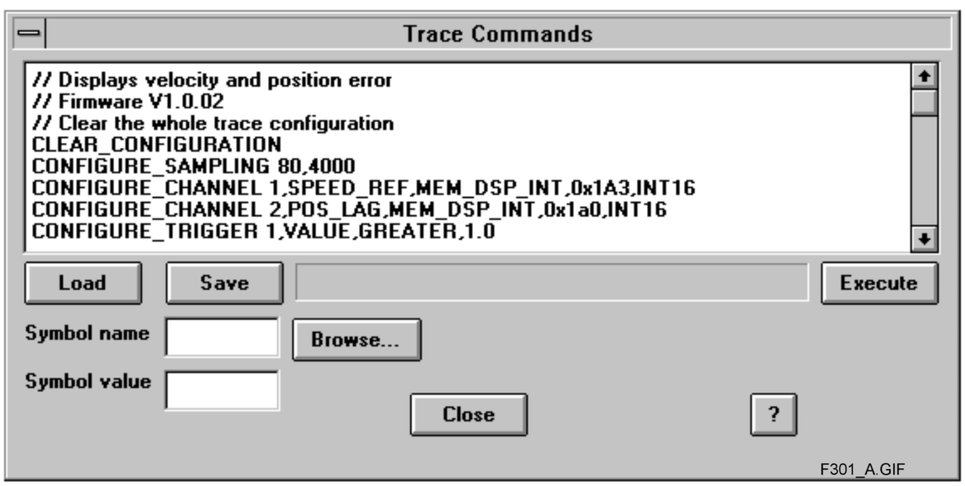


Figure 5 Trace Commands Dialog Box

Figure 6 Trace Control Panel

Related Field	Symbol	Mem. Type	Type	Units (1 lsb = …)
Rf_SPEED_REF	SpeedRef	MEM_DSP_INT	INT16	0.915 t/min @ 8kHz
Rf_ACCEL_REF	AccelRef	MEM_DSP_INT	INT16	3433.23 t/min^2 @ 8kHz
Rf_POS_LAG_16	PosLag	MEM_DSP_INT	INT16	2^{-16} t
Rf_TORQ_FLOW	TorqFlow	MEM_DSP_INT	INT16	4096 = stall Torque
Rf_TORQ_QUIET	TorqQuiet	MEM_DSP_INT	INT16	4096 = stall Torque
Rf_TORQ_REF	TorqRef	MEM_DSP_INT	INT16	4096 = stall Torque
Rf_IKAN	Ikan	MEM_DSP_INT	INT16	
Af_UDCBus	UdcBus	MEM_DSP_INT	INT16	4096 = Udc max
Af_IQRef	IQRef	MEM_DSP_INT	INT16	4096 = Imax
Af_IQMes	IQMes	MEM_DSP_INT	INT16	4096 = Imax
Mf_SIN_A	Sina	MEM_DSP_INT	INT16	
Mf_COS_A	Cosa	MEM_DSP_INT	INT16	
Mf_POS_RES	PosResB	MEM_DSP_INT	INT16	2^{-16} t
Of_INPUTS_VALUES	Inputs	MEM_960	BIN16	
none*	Setpoint	MEM_960	INT32	$27.94 \cdot 10^{-6}$ t/min (CPU=2kHz)

Table 6 Most interesting variables to trace
**) it represents the pipe_position of PAM*

Units depending on the working frequency (4 or 8 kHz) are calculated as follow:

SpeedRef given units in the filed list: 2^{-19} t/POS REG period
we have then, at 8 kHz:

$$\frac{2^{-19}}{\left(\frac{1}{8000}\right)} \bullet 60 = 0.915 turn/\min$$

AccelRef given units in the filed list: 2^{-26} t/POS REG period
we have then, at 8 kHz:

$$\frac{2^{-26}}{\left(\frac{1}{8000}\right)^2} \bullet 60^2 = 3433.23 turn/\min^2$$

Setpoint units are 2^{-32} t/MAIN CPU period. MAIN CPU period is 2 kHz then:

$$\frac{2^{-32}}{\left(\frac{1}{2000}\right)} \bullet 60 = 27.94 \bullet 10^{-6} turn/\min$$

Interpreting and utilizing the Trace Display

The trace display includes a number of useful features and capabilities to aid in measuring and analyzing the captured data including movable markers, an optional grid and zooming capability.

Components of Basic Trace Display

This paragraph provides a description of the components of a trace and how they are utilized and interpreted. Figure 7 shows a two variables trace with components identified.

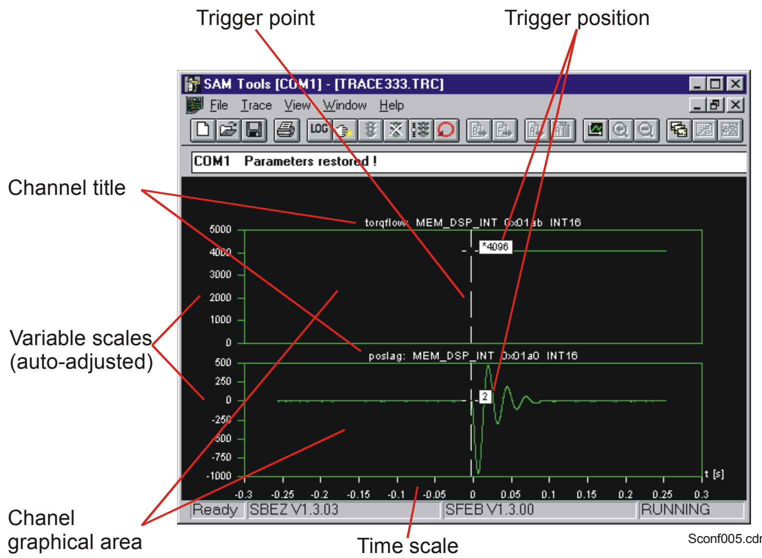


Figure 7 Trace window

Time Scale - Shows the time reference for the trace data. The time scale is a function of the sample rate specified in the Trace Command file associated with the trace data. Time t = 0 is the trigger point (point at which the trigger condition is satisfied). The pre and post trigger percentages displayed are set by command in the Trace Command file.

Variable Scale - The graphical display of each variable is adjusted automatically to show the full excursion of the variable over the sampling interval within the available vertical space and the variable scale shows the relationship between vertical amplitude of the variable and it's actual value. Units of the variable scale are the units of the variable (see Table 6).

Note that the variable scale for successive traces of a variable may be different if the total excursion of the variable changes.

Trigger Point - This dashed vertical line indicates the point at which the trigger condition is satisfied. This point becomes the time origin (t = 0) for the trace.

Trigger Position - The position (or value) of each variable at the trigger point.

Channel Title - This is a four part expression comprised of a channel label, memory type, memory address and data type. Channel label is a user-defined name for the variable, memory type and memory address define the location of the variable is the SAM Drive's RAM memory and data type defines the format (i.e. integer, real, etc.) of the variable.

Channel Graphical Area - Portion of the channel in which trace data is plotted. The areas at the left and right extremes of each channel graph are outside the graphical area.

Trace Markers

Two trace markers (M1 & M2) are available for making precise measurements from graphical trace data. The value of each variable at it's point of intersection with the marker is displayed along with the position (it time) of each marker. In addition the delta t and delta values for each channel are displayed on the trace.

To position a trace marker on a displayed trace, position the mouse pointer over the desired point, hold down the SHIFT key, then click on the left or right mouse button (left button to position M1 or right button for M2). Markers are not saved when a trace file is closed.

Markers may be alternately hidden or shown by selecting MARKER from the VIEW menu.

Grid

A grid may be alternately applied or removed from the graphical display area of a trace by selecting GRID from the VIEW menu.

Trace Zoom Feature

The zoom feature may be used to magnify a portion of a trace, Two zoom modes, time zoom and area zoom are available. Time zoom takes a selected portion of the trace and expands it horizontally to fill the trace display area. Area zoom expands the selected area of a single channel to fill the display area. When a trace is expanded the time and variable scales are adjusted accordingly to retain a calibrated image. Any sector of a trace within the graphical area of a channel may be zoomed. When zooming is possible a magnifying glass symbol is displayed beside the mouse pointer. Zoomed traces may be printed but not saved.

Perform the following steps to time zoom a trace:

1) Position the mouse pointer inside the graphical area of a channel at one end of the area to be expanded. The magnifying glass symbol must be visible next to the mouse pointer indicating that zooming is possible.
2) Press and hold the left mouse button.
3) While holding the mouse button down, move the mouse pointer left or right and up or down as necessary to “box in” the area to be expanded.
4) Release the mouse button. An expanded display of the selected area is created.
5) To return to the previous version of the trace select PREVIOUS from the VIEW menu. To return to the original version of the trace, select ORIGINAL from the VIEW menu.

In order to zoom on area of a trace, perform the following steps:

1) Position the mouse pointer inside the graphical area of a channel at one corner of the area to be expanded. The magnifying glass symbol must be visible next to the mouse pointer indicating that zooming is possible.
2) Press and hold the right mouse button.
3) While holding the mouse button down, move the mouse pointer left or right to the other end of the area to be expanded. As the pointer is moved a box encloses the selected area.
4) Release the mouse button. An expanded display of the selected area is created.
5) To return to the previous version of the trace select PREVIOUS from the VIEW menu. To return to the original version of the trace, select ORIGINAL from the VIEW menu.

Test Device

The SAM Test Device is an optional tool, which can be inserted between the SAM RS232 servicing plug and the Service PC cable. With this device, two internal variables can be available on two analog outputs, i.e. for monitoring on an oscilloscope.

The “analog.pan/t_device.pan” panel (see Figure 8) allows selecting which variable is displayed on which output.

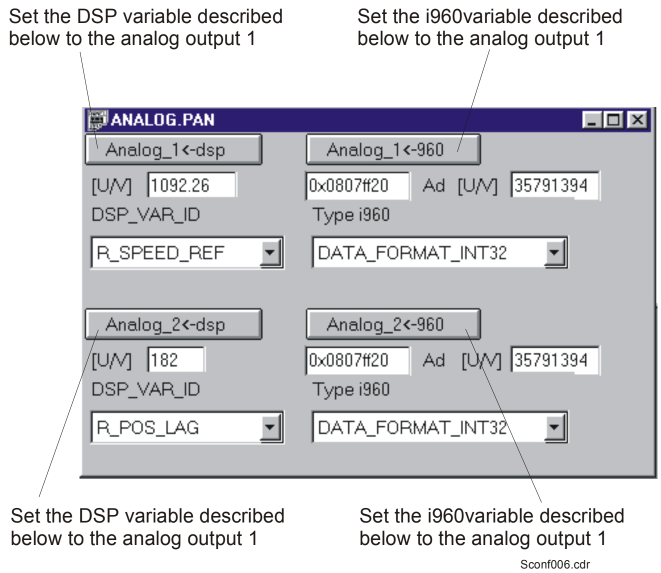


Figure 8 Test Device “Analog” panel

DSP variables can be selected directly within the scrolling list.

i960 variables have to be defined with their addresses and their size (see ProMotion.hlp, “Trace information” section).

For both types of variable (DSP and i960) the scale factor (units/volts) has to be defined as in following examples:

SpeedRef given units in the filed list are
2^{-19} t/POS REG period
which give at 8 kHz: 0.915 t/min.

It means that 1 lsb of the SpeedRef variable represents 0.915 t/min. Then, if we want, for example 1V/1000 t/min, scale factor will be:

$$\frac{1000}{0.915} = 1092.26 units / volt$$

PosLag given units in the filed list are
2^{-16} t
which give: 5.49 10^{-3} degree.

It means that 1 lsb of the PosLag variable represents 5.49 10^{-3} degree. Then, if we want, for example 1V/1deg, scale factor will be:

$$\frac{1}{5.49 \bullet 10^{-3}} = 182 units / volt$$

SAM Operating Software

Introduction

The functionality of SAM Drive comes largely from its resident operating software. The functions are distributed among its two microprocessors. Figure 9 highlights the principal software functions and shows links between software and hardware functions.

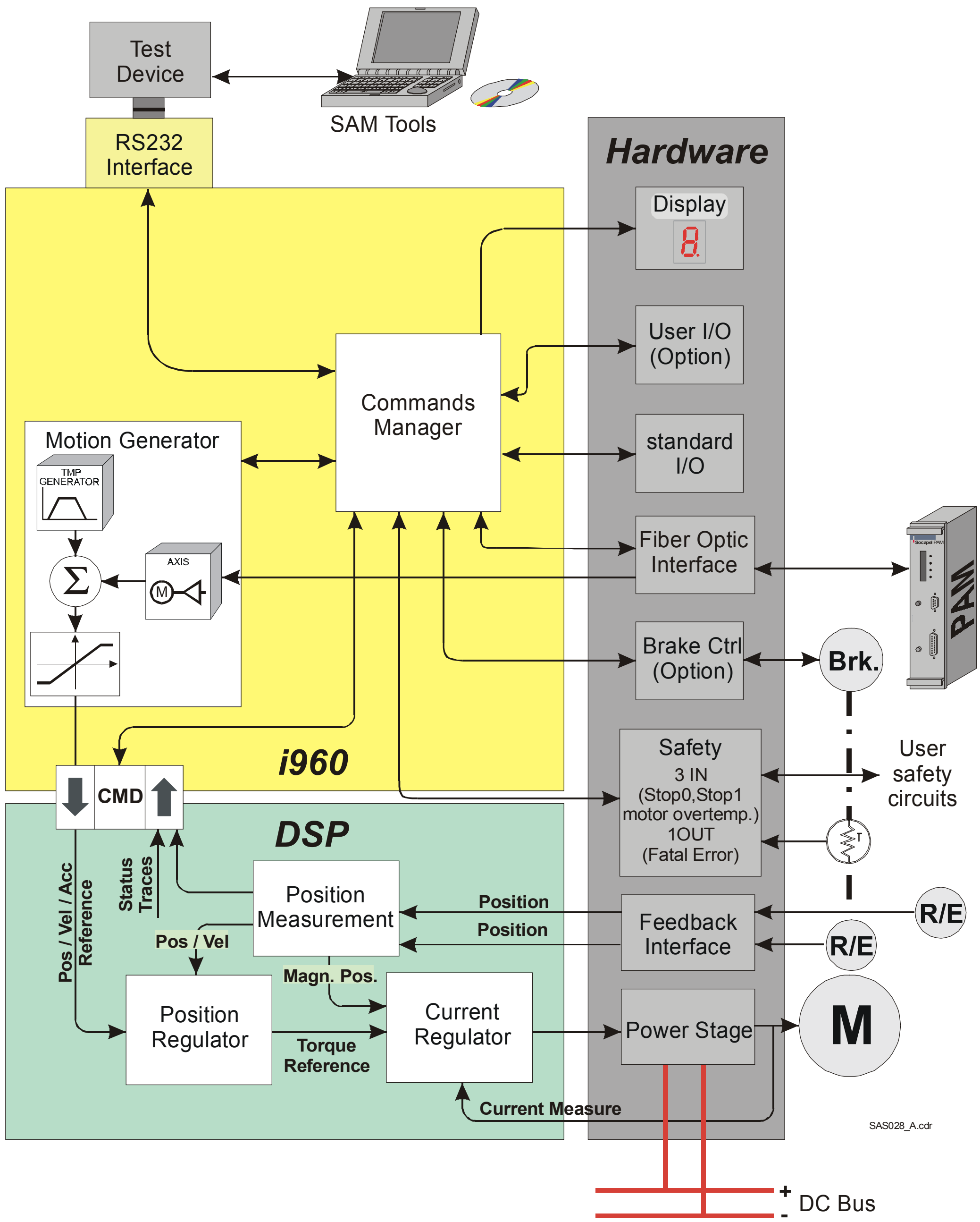


Figure 9 SAM Drive Software Functions

Definitions

Commands Manager

The Commands Manager handles communications with PAM, application program (Sequence) execution and coordinates activities within the SAM. Using a dedicated RS-232 port, it communicates with a PC running SAM Tools and a “Test Device” accessory.

Motion Generator

The Motion Generator executes those portions of various pipe block functions, which are implemented at the axis level. Secondly, it generates independent motion profiles including point to point and continuous motions in response to commands and parameters from the application program.

A “Limiter” compares the flow of motion data against limiting values of positive and negative travel, speed, acceleration/deceleration, torque and direction imposed by the application. Whenever a trajectory values exceeds a limit, the limiter sets an appropriate status bit, which is normally used to stop the motion. The user normally establishes limiter parameters, based on the application’s requirements.

Position Controller

The Position Controller (see Figure 10) is a firmware algorithm that provides field proven, closed loop PID control with enhanced feed-forward compensation. A notch filter, which can be activated and tuned by parameter, may be utilized to improve system performance in the presence of strong torque disturbances when a mechanical resonance frequency might otherwise limit the closed loop pass-band.

The Position Controller, employing totally digital techniques, provides the benefits of precision and repeatability. Two SAM Drives with identical tuning parameters respond identically in the same axis environment.

Other Controller operating modes including speed controller, open-loop vector-controlled operation and direct torque control can be selected. A position feedback device (typically a resolver or encoder) provides velocity and position feedback to the Position Controller.

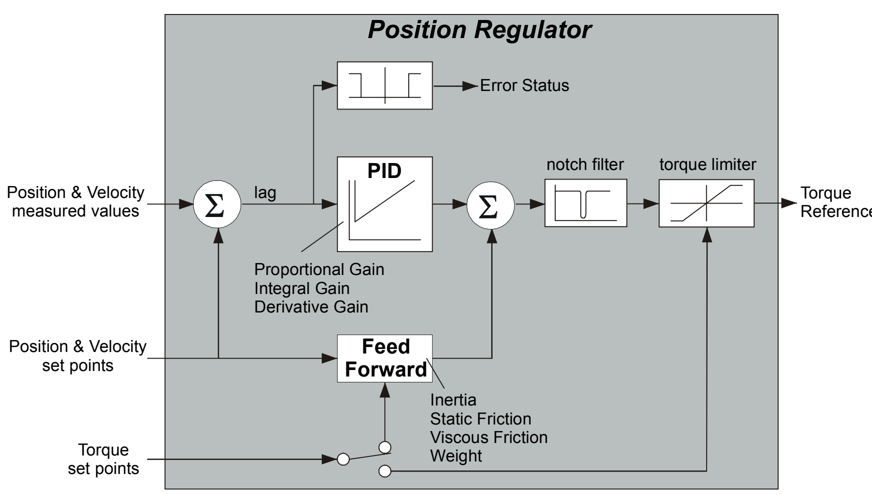


Figure 10 Position Controller Functional Diagram

Position Measurement

The Position Measurement function, utilizing input from the Feedback Interface, provides measured position and velocity data. Position feedback is used by the Current Controller for commutating the motor currents and by the Position Controller for regulating motor speed and position.

Current Controller

The Current Controller is a closed loop controller, which supplies a three-phase pulse width, and sine wave modulated current command to the Power Stage. It monitors the output currents and regulates the direct (I_D) and transverse (I_G) current components. The Current Controller employs totally digital control, which provides improved performance and repeatability compared to standard analog technology. Control algorithms for AC synchronous motors (AC Servo motors) and asynchronous motors (AC induction motors) are built in and selectable by parameter.

A downloadable parameter file, which correctly configures the Current Controller and Power Stage, is available for every model servomotor that is available together with the PAM and SAM System. Configuration files for other types of motors are also available.

Built-in thermal load modeling of the axis motor utilizing motor and drive parameters provides reliable and responsive motor overload protection under all operating conditions.

Status Registers

Four 16-bit status registers provide a complete picture of SAM current operational state with respect to error, fault and alarm conditions. For easier and quicker event detection, a fifth 16 bit Main Status register provides a summary picture of SAM current operational state.

Operating States

SAM software controls in a very strict way in which "state" the Drive is. Depending on the actual state, several actions and transitions are possible and others are not.

SAM state is displayed on its front-panel.

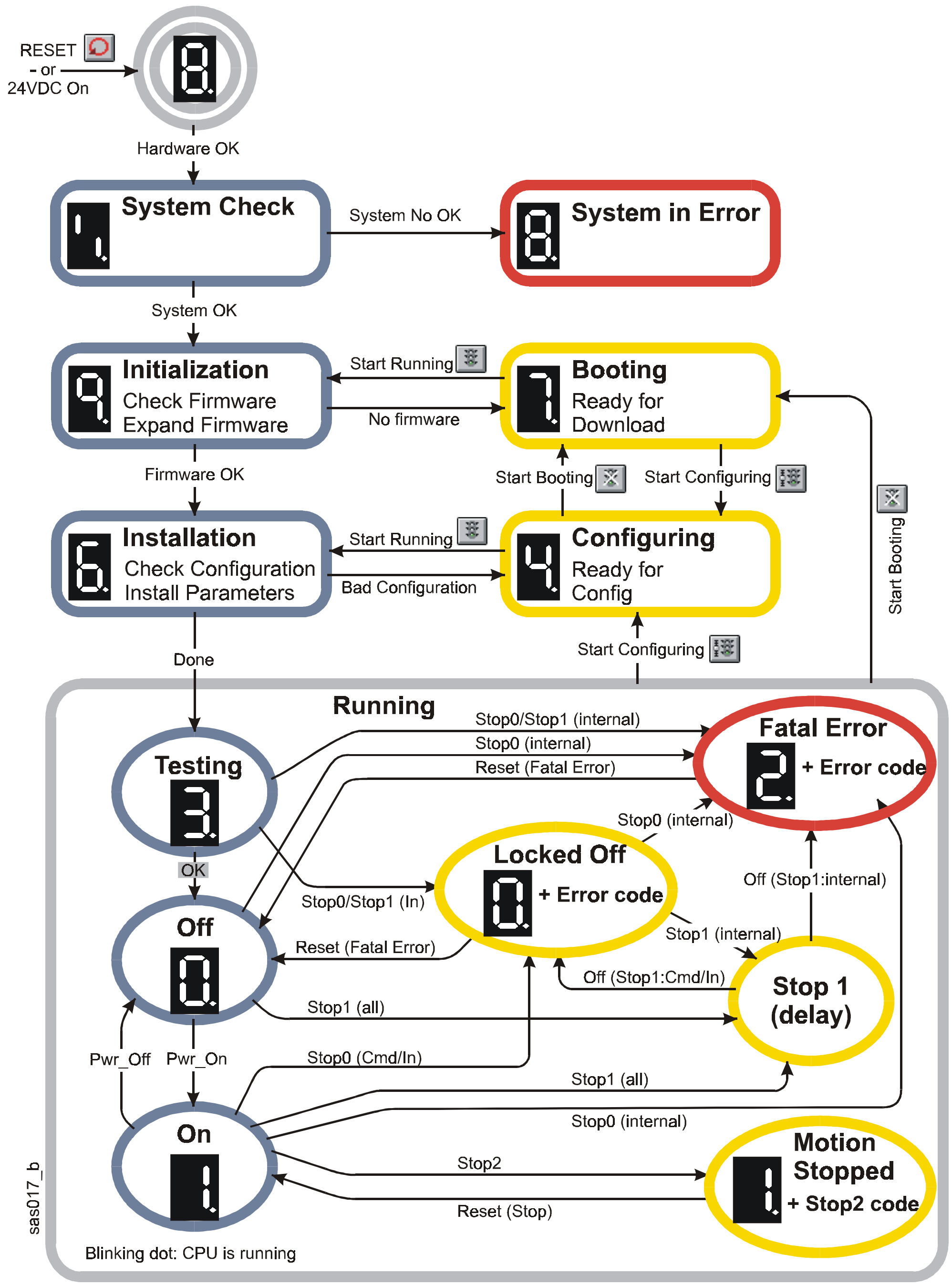


Figure 11 Operating software Initialization phase

Initialization

A compressed version of the operating software (also named “Firmware”) along with an uncompressed copy of a Boot-up program (also named “Bootware”) and all parameters reside in nonvolatile flash EEPROM. Upon startup, the Bootware is copied into RAM and executed. It performs some hardware and communication initialization, then copies the Firmware (decompressed) and parameters into RAM. CRC checking is used to verify the integrity of the RAM contents.

Execution of the operating software begins with the Configuration phase during which all SAM Drive adjustments and settings are established digitally using either default parameter values from flash EEPROM, or configuration files previously downloaded from a host or service PC running SAM Tools. SAM may be commanded to “save” parameters, upon which the current values of all parameters are stored in flash EEPROM. A host or service PC may upload a complete parameter set for archiving a configuration.

Run-Mode

Upon completion of the Configuration phase, the operating software enters the run-mode phase, which handles communication with the host, commands execution and finally controlling the motor.

SAM Position Controller - Its Tuning

Introduction

Section titled “SAM Position Controller Principles” discusses and illustrates the concepts, terms and equations utilized in the tuning procedures. A block diagram and description of the Position Controller is included in this introductory section.

This chapter presents next step by step procedures for tuning a SAM Drive.

SAM Position Controller Principles

Short Description

SAM Drives incorporate a modern, flexible closed-loop controller (called the “Controller” or “Position Controller”) which is responsible for keeping an axis on it’s required speed and position trajectories.

Closed-loop control is required for compensating indeterminate disturbances (disturbances of unpredictable magnitude or timing). If indeterminate disturbances are significant relative to the required accuracy, only comparatively high PID loop gains can provide the necessary precision. However, with higher PID loop gains comes the classic compromise of precision vs. stability. Position overshoots are also very common.

The effects of known disturbances such as inertia (during acceleration), friction and others are most easily eliminated using **feed-forward compensation** rather than high position loop gain. If indeterminate disturbances are small, the required accuracy may be achieved mainly using feed-forward compensation with lower controller loop gains and less chance for stability problems. The integral gain can also be set to zero, as in a simpler PD control scheme, so that no position overshoot occurs.

Software Objects regarding Position Control

The Controller is software based and employs digital signal processing techniques. The Controller is tuned by adjusting its parameters to achieve desired performance. Using standard control panels and traces supplied with SAM Tools, drive tuning is accomplished quickly and easily following the procedure in this chapter.

Figure 12 shows a functional diagram of the Position Controller. Parameters and fields accessible to the user are labeled.

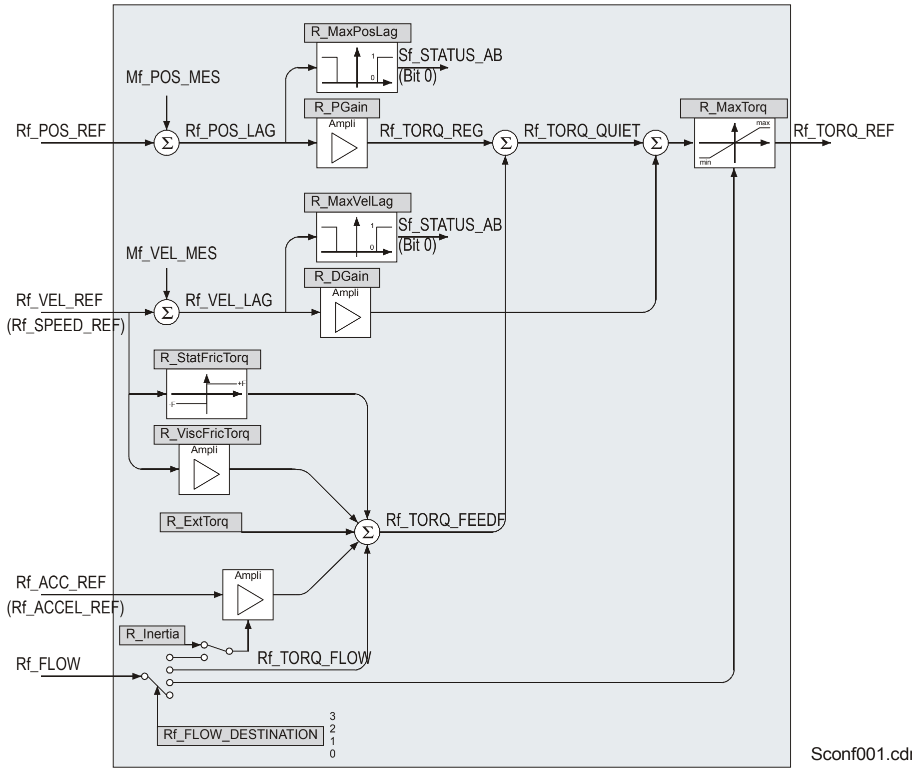


Figure 12 PD Position Controller

A short listing and description of Controller parameters is found in Table 7, such as set gains, thresholds or clamping limits for various functional elements of the Controller. **Detailed list is available in ProMotion Help "SAM Parameters and Fields" topic.**

The more dynamic Controller input and output variables are defined as fields, and presented in Table 8.

All Controller parameters begin with the prefix "R_" or "Ri_" (e.g. R_PGain). Controller fields prefix is Rf.

parameter name	description
R_DGain	sets derivative gain of controller
R_ExtTorq	torque input when controller is in external command mode
R_IGain	integral gain of controller
R_Inertia	sets inertia feed-forward compensation gain
R_MaxPosLag	sets threshold value for position lag error
R_MaxTorq	sets upper torque limit
R_MaxVelLag	sets threshold value for velocity lag error
R_PGain	sets proportional gain of controller
RStatFriqTorq	sets static friction torque feed-forward compensation value
RViscFricTorq	sets viscous friction torque feed-forward compensation gain
Ri_RegMode	sets Controller working mode:

Table 7 Short listing of Controller Parameters

field name	description
Rf_ACC_REF	acceleration command from TMP Generator
Rf_POS_LAG	position error
Mf_POS_MES*	axis position from position feedback device
Rf_POS_REF	position command from TMP Generator
Rf_TORQ_FEEDF	torque feed-forward command
Rf_TORQ_FLOW	torque flow command from external flow input
Rf_TORQ_QUIET	component of torque command
Rf_TORQ_REF	composite torque command
Rf_TORQ_LIM	current torque limit
Rf_VEL_LAG	velocity error
Mf_VEL_MES*	measured axis velocity
Rf_VEL_REF	velocity command from TMP Generator

Table 8 Short listing of Controller Fields;
Measured position and velocity values (Mf_POS_MES and Mf_VEL_MES) are Main Sensor fields (and not Controller fields). Their prefix is thus "Mf_".

Some Theory regarding PD Position Control

Referring to the block diagram of a proportional plus derivative control system shown in Figure 12, let us first define the following terms:

K_D	speed loop gain
K_P	position loop gain
speed	speed feedback, the measured speed of the axis
position	position feedback, the measured position of the axis
speed lag	difference between commanded and measured speed
position lag	difference between commanded and measured position
position ref.	commanded or set point position
speed ref.	commanded or set point speed
J	motor plus load inertia

The tracking precision, that is the ability of the axis to remain on it's trajectory in the face of disturbances, depends on position loop gain; however, this loop by itself is unstable due to the double integration. The speed loop serves to stabilize the system. For a given axis configuration, position loop gain, speed loop gain and their ratio have a range of values which produce optimum axis performance. Outside this range tracking precision degrades or the axis becomes unstable.

From control system theory two terms, "speed loop cutoff frequency" (F_{CV}) and "position loop cutoff frequency" (F_{Cp}), are very useful for determining optimum values of position loop gain and speed loop gain. The cutoff frequency is the frequency at which the output amplitude is reduced by a factor of 2 (6 dB) compared to the output amplitude at zero Hertz.

For a sinusoidal **speed reference**, at cutoff frequency (F_{CV}):

$$speed = \frac{speedreference}{2} = speedlag$$

$$speed = \frac{1}{2\pi \bullet F_{CV}} \bullet acceleration$$

$$acceleration = \frac{speedlag \bullet K_d}{J}$$

Therefore:

$$F_{CV} = \frac{1}{2\pi} \bullet \frac{K_d}{J}$$

For the position loop with a double integral,

$$position = \left(\frac{1}{2\pi \bullet F_{CP}}\right)^2 \bullet acceleration$$

Therefore:

$$F_{CP} = \frac{1}{2\pi} \bullet \sqrt{\frac{K_P}{J}}$$

The ratio $\frac{F_{CV}}{F_{CP}}$ is called the damping ratio.

When the damping ratio is > 1 a system is referred to as over-damped, when the damping ratio is < 1 a system is under-damped.

When the damping ratio = 1 the system is critically damped. A critically damped system provides classically stable operation with optimum response (best compromise for minimum overshoot with short settling time). In that case:

$$F_{CV} = F_{CP}$$

Then,

$$\sqrt{\frac{K_p}{J}} = \frac{K_d}{J}$$

Therefore:

$$K_P = \frac{K_d{}^2}{J}$$

This relationship is important because it shows that for constant damping, K_p is proportional to $K_d{}^2$. This means that in order to maximize K_p (and therefore minimize position lag) while maintaining stability, K_d must be made as large as possible.

In practice, K_d is limited by several factors including the SAM Drive current loop bandwidth which is directly related to the PWM frequency selected for the drive (standard: 8 kHz; optional: 4 kHz). Other factors including resonance frequency of the axis mechanics and signal to noise ratio of the speed measurement limit how large K_d can be.

In practice K_d is increased to the point where the axis goes into sustained oscillation, then reduced by a factor of 2 to obtain good speed loop stability. K_p is then determined using the relationship $K_P = \frac{K_d^2}{J}$ and fine tuned, if desired, using a step response test.

PD Controller Performance verses Tuning

Figure 13 shows the response of a SAM Drive and AHR 142C6 motor to a step torque disturbance equal to stall torque of the motor. In Figure 13, the Controller is tuned for critically damped response (F_{cp}=F_{cv}=50Hz). Note that the motor overshoots once by about 20% then settles to a steady state position lag of 1050 units (~ 5.8 degree).

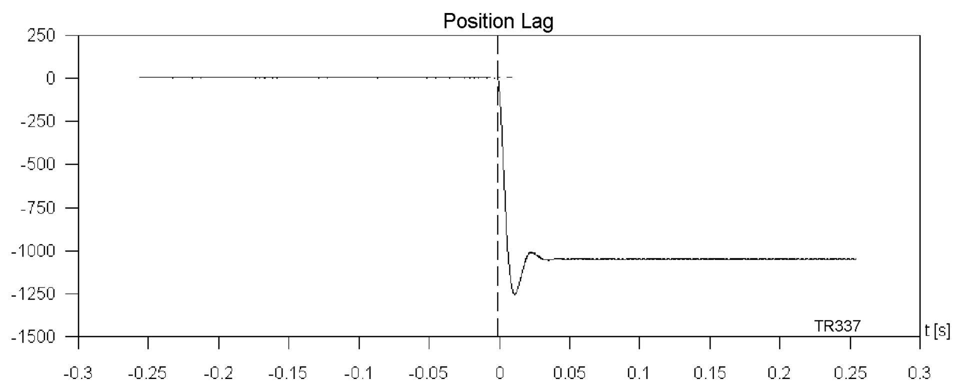


Figure 13 PD Control - Critically Damped Response

Figure 14 shows the same system response with F_{cv} = 50 Hz and F_{cp} = 25 Hz (damping ratio = 2, over-damped). Note that at this damping ratio there is no overshoot; however, the settling time is longer and the steady state position lag is four times greater due to the reduction in position loop gain.

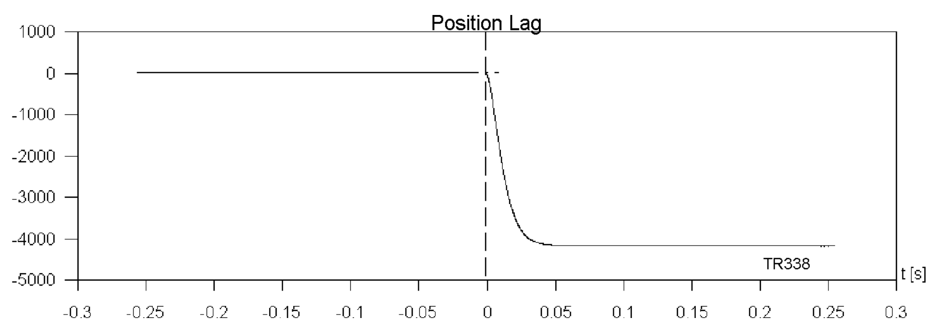


Figure 14 PD Control - Over damped Response

Figure 15 shows the same system response when F_{cv} = 50 Hz and F_{cp} = 100 Hz (damping ratio = 0.5, under-damped response). Note that the overshoot is significantly larger and settling time has increased, but steady state position lag is smaller due to increased position loop gain.

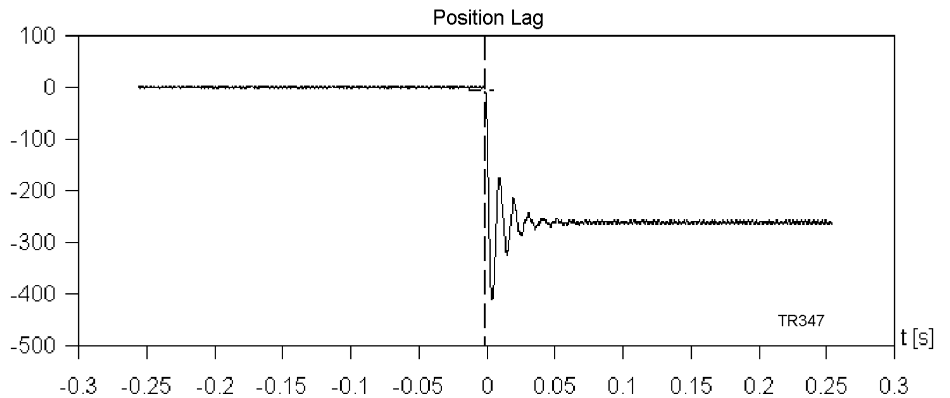


Figure 15 PD Control - Under damped Response

Some Theory regarding PID Position Control

PID control is similar to proportional plus derivative control but includes an additional loop with a gain (K_i) and an integrator. This additional loop serves to eliminate static position lags resulting from static disturbances. This loop can only correct static disturbances or disturbances with frequencies below it's cutoff frequency (F_{ci}). This loop is by itself unstable due to the three integrations and is stabilized by the other two loops.

Unlike the proportional plus derivative case, F_{ci} cannot be set equal to F_{cp}. Stable operation is typically obtained at:

$$F_{cv} = F_{cp}$$
$$F_{ci} = 0.63 \bullet F_{cp}$$

with:

$$K_I = 0.25 \bullet \frac{K_p^{\ 1.5}}{\sqrt{J}}$$

Higher system stability is achieved by setting $F_{cp}<F_{cv}$ and $F_{ci}<0.63 \cdot F_{cp}$. The system response may be fine tuned using a step response test.

PID Controller Performance verses Tuning

Figure 16 shows the effect of adding integral control to a proportional plus derivative control loop. In this illustration F_{cp} and F_{cv} are the same (50 Hz) as the critically damped PD case (see Figure 13), and $F_{ci} = 0.63 \bullet F_{cp} = 32Hz$.

Note that the initial response (for the first 10 ms) is about the same as Figure 13, but, as a result of the integral feedback, static position lag is reduced to zero.

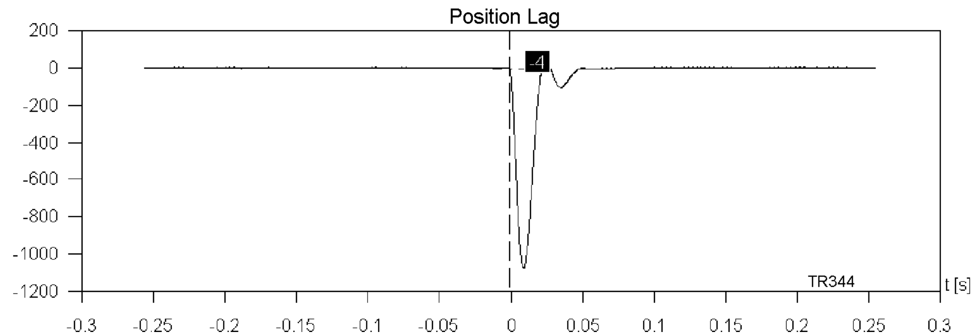


Figure 16 PID Control - Critically Damped Response

In Figure 17, $F_{cv}=F_{cp}=100Hz$ and $F_{ci}=63Hz$. All three cutoff frequencies are increased by 100% compared to Figure 16, resulting in a significant reduction of position lag and settling time. Because the ratios of cutoff frequencies remain the same, the general shape of Figure 16 is the same as Figure 17.

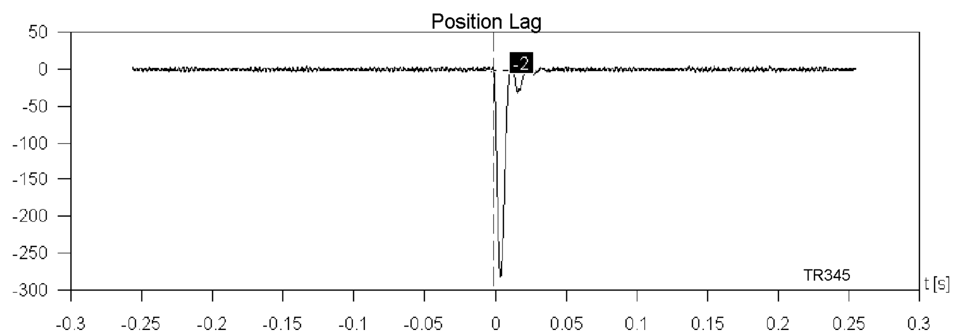


Figure 17 PID Control - Response with increased Cutoff Frequencies

Figure 18 shows the effect of reducing F_{cp} to 35 Hz. F_{ci} is reduced to 20 Hz in order to retain $F_{ci} = 0.63 \bullet F_{cp}$. The reduction in F_{ci} and F_{cp} increases stability but slows the response.

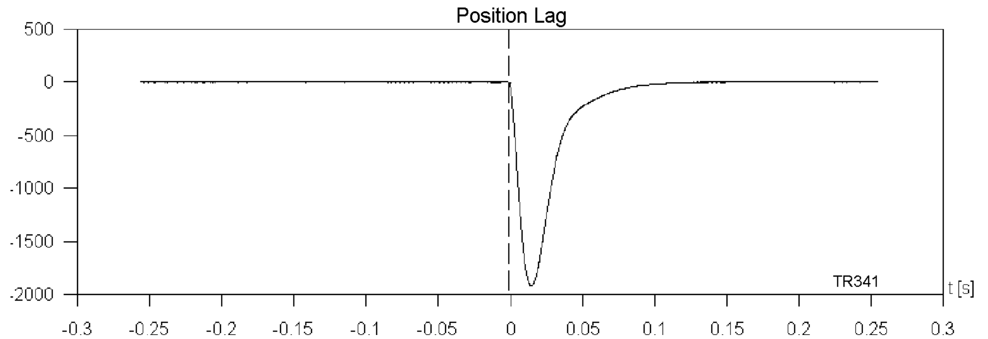


Figure 18 PID Control – Over-damped Response

Figure 19 shows decreased stability when F_{ci} is increased to 40 Hz, thus increasing F_{ci}/F_{cp} to 0.8, while keeping $F_{cp} = F_{cv} = 50Hz$.

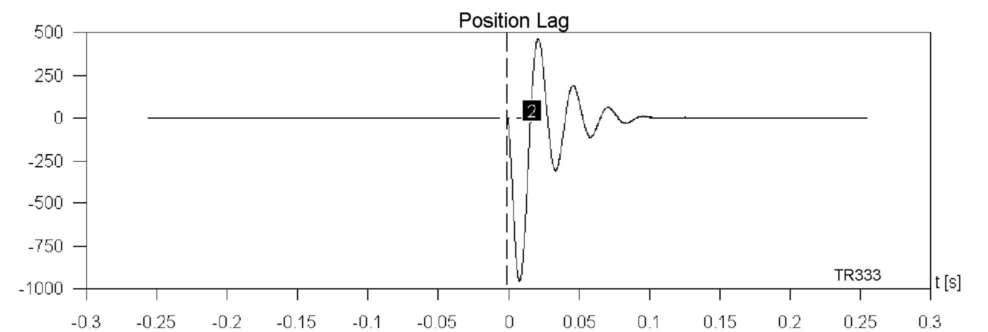


Figure 19 PID Control - Under-damped Response

In Figure 20, F_{cp} is reduced to 35 Hz with $F_{ci} = 32Hz$ and $F_{ci}/F_{cp} = 0.91$. The result once again is decreased stability.

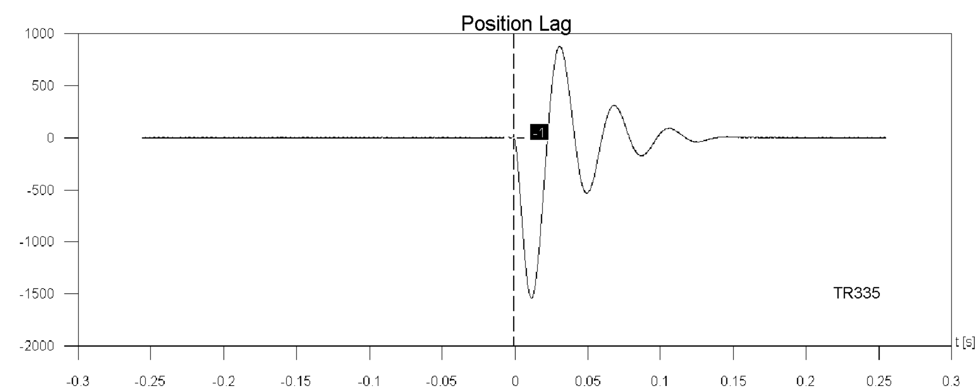


Figure 20 PID Control - Under-damped Response

Some Theory regarding Feed-Forward Compensation

When a driven system and it's behavior are well known, it is possible to create a simplified mathematical model which takes into account the influences of disturbances such as weight, static and viscous friction and the effect of load inertia during acceleration/deceleration. With a degree of precision which increases the closer the model comes to reality, the torque necessary for each movement may be calculated and applied directly to the motor independent of any feedback. Due to its "open-loop" nature, feed-forward compensation does not contribute to axis instability and it is simple to setup. In many applications, utilization of feed-forward compensation provides improved trajectory tracking accuracy using a less complex Position Controller mode, with lower gains, improved stability, and no position overshoot. The Position Controller remains active. It functions to compensate for the remaining differences between the model and real system.

Figure 9 on page 26 shows SAM implementation of feed-forward compensation:

- For inertia compensation, a torque component proportional to acceleration is created
- For viscous friction, a torque component proportional to speed is added
- For "dry friction", a constant torque component with sign based on the speed reference is summed into the composite torque command
- For weight, a torque component equal to a parameter setting is added

Benefits of using Feed-Forward – an example

Figure 21 shows the response of a critically damped proportional plus derivative axis when commanded to move 1800 degrees (5 turns) at a velocity of 9000 degrees/sec. and an acceleration of 360,000 degrees/sec^2. The upper trace of Figure 21 is the velocity profile of the move and the lower trace shows position lag.

Note that position lag increases significantly during the acceleration and deceleration portions of the move due to the effects of the motor plus load inertia which cannot be totally removed by the Controller's position loop gain. During the constant speed portion of the move, average position lag is approximately +50 due to the static and viscous friction produced by the motor and load. The AC component of position lag during the constant velocity portion of the move is due to the inherent cyclical error of the resolver providing position and velocity feedback for the axis.

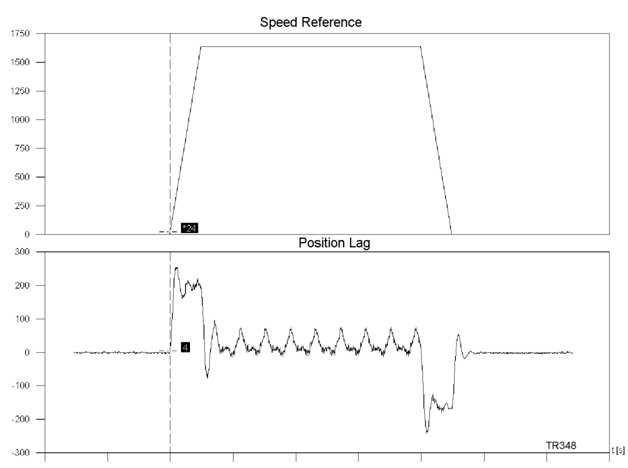


Figure 21 PD Axis Response without Feed-forward Compensation

Figure 22 shows the same move with the Controller operating in PID mode and adjusted for optimum response. The action of the integral feedback loop tends to drive position lag toward zero during the intervals of constant acceleration and constant speed; however, the peak to peak position lag is not reduced.

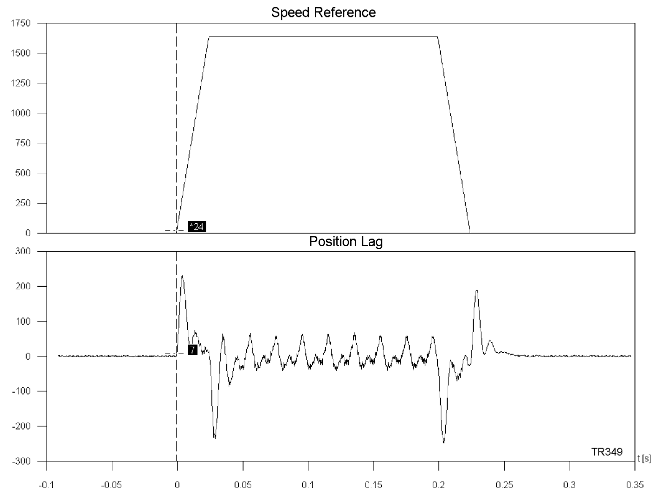


Figure 22 PID Axis Response without Feed-forward Compensation

Figure 23 shown the axis response to the same move following introduction of feed-forward compensation in the Controller.

In this example, the Controller is configured as a proportional plus derivative controller with the same proportional and derivative gain settings as for Figure 21. Static friction, viscous friction and inertia compensation parameters, which were previously zero, have been adjusted to the correct values for the motor and its load. Due to the auto scaling feature of the SAM Tools Trace function, the position lag appears larger than previous examples, but peak to peak position lag is now approximately 110 (an **80% reduction**) and average position lag is nearly zero.

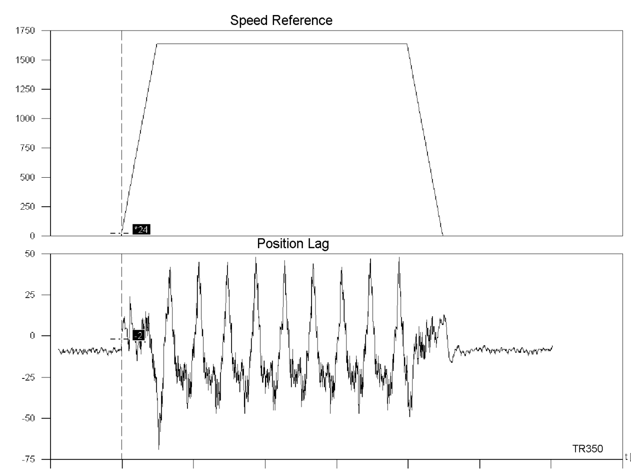


Figure 23 PD Axis Respond with Feed-forward Compensation

Converting SAM Controller Parameters to "usual" units

Listed below are the SAM system-specific equations and relationships corresponding to those listed in this general discussion of tuning principles.

$$K_D = R\_DGain \bullet \frac{M\_StallTorq}{2\pi \bullet 1000}$$

$$K_P = R\_PGain \bullet \frac{M\_StallTorq}{4\pi}$$

$$K_I = R\_IGain \bullet M\_StallTorq \bullet \frac{8000}{2\pi \bullet 512}$$

$$F_{cv} = \frac{1}{2\pi} \bullet R\_DGain \bullet \frac{M\_StallTorq}{J} \bullet \frac{1}{2\pi \bullet 1000}$$

$$F_{cp} = \frac{1}{2\pi} \bullet \sqrt{R\_PGain \bullet \frac{M\_StallTorq}{J} \bullet \frac{1}{4\pi}}$$

$$F_{ci} = \frac{1}{2\pi} \bullet \sqrt[3]{R\_IGain \bullet \frac{M\_StallTorq}{J} \bullet 1.35}$$

SAM Drive Tuning Procedure

Overview

This section presents step by step tuning procedures. Tuning parameters are entered and adjusted using standard control panels provided with SAM Tools. Axis responses are captured and displayed on a PC monitor using the SAM Tools traces feature.

Preliminaries to Tuning

Prior to beginning any axis tuning procedure, the SAM Drive must be properly configured with the correct motor parameters for the axis configuration. Any fault or error conditions must be eliminated. A PC running SAM Tools and a SAM to Service PC test/monitoring cable (ACC p/n 9032 010 689) are required to perform the procedure.

To properly tune a SAM Drive the actual axis mechanical load should be connected to the motor. In that case the system integrator must be very careful for not ordering any motor movement that can be destructive or dangerous while tuning.

Load simulators (i.e. inertia wheels) are useful for preliminary setup, but are not recommended when performing final controller adjustments because they seldom duplicate the behavior of the actual axis load.

The axis load must be tightly coupled to the motor. Free-play or backlash between the motor and load complicates the tuning process and prevents satisfactory performance in most applications.

The optimum controller adjustment is not necessarily with all gain settings just below the point of instability. A preferable strategy is to adjust the Controller to a point where the desired performance is achieved with some additional margin.

The process of tuning may subject motors, SAM Drives and Dynamic Braking Resistors to conditions exceeding the operating conditions encountered during execution of the application for which the SAM system components were sized. SAM System components are protected against overloads, but system integrators must be cognizant of this possibility, and not operate the equipment outside its limits.

Motors may run faster or slower than expected, or in the opposite direction, or even go into oscillations.

System integrators must take necessary precautions such as limiting maximum torque to prevent erratic motor operation from harming personnel or the driven equipment or the machine.

Select the Position Controller Operating Mode

The SAM Position Controller may be configured by parameter to operate in any of the modes listed in Table 9, which also summarizes important performance characteristics of each Controller mode. Select an operating mode based on the axis configuration and performance required then tune the Controller using the adjustment procedures for the operating mode selected.

Controller Mode	Performance Characteristics
PD position control	Classical PD (proportional plus derivative) control loop. Average speed lag is zero. Static position lag is proportional to disturbance torque.
PID position control	Classical PID (proportional plus integral plus derivative) control loop. Average speed lag is zero. Static position lag in response to a disturbance torque is zero.
torque control	Front end of Position Controller is disabled. Application controls torque output directly.
free	Position Controller produces a rotating current vector. This mode is used for motor wiring check.

Table 9 Position Controller Modes

PD Controller Adjustment Procedure

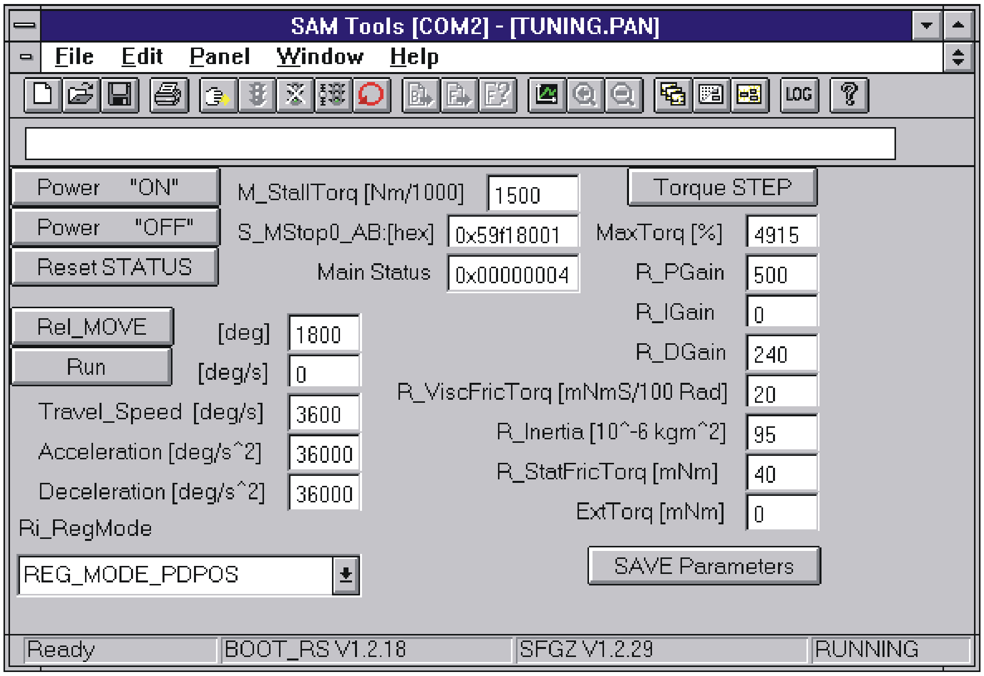
This paragraph presents the step by step procedure for tuning any SAM Drive whose Position Controller is to be configured to operate in PD or PID mode.

i

Step 1 through step 18 of this procedure are also used when adjusting a PID Controller

1) Connect the Service PC running SAM Tools to the Service port of the SAM Drive to be tuned.
2) Verify SAM Drive to Service PC communications by performing a handshake.
3) Setup the trace titled “TUNING.STC” (see Table 5, page 20). TUNING.STC is found in the Promotion “CMDS” subdirectory.

4) Activate the control panel titled “TUNING.PAN”. TUNING.PAN is found in the Promotion “PANELS” subdirectory.



SConf002.cdr

Figure 24 Tuning Control Panel with Least Significant digit of M_Stop0_AB Designated

5) On the TUNING control panel, record the current value of the least significant digit of S_MStop0_AB (see Figure 24)

i

Do not forget to record the current value of S_MStop0_AB, as it will have to be introduced again at the end of the tuning procedure.

6) Now change the least significant digit of S_MStop0_AB to “0”. This is necessary to prevent position lag from causing a STOP 0 during tuning.
7) In the Ri_RegMode list entry box, select “REG_MODE_PDPOS”.
8) Set R_IGain, R_PGain, R_Inertia, R_StatFricTorq, and R_ViscFricTorq = 0.
9) If the required speed loop cutoff frequency (F_{CV}) and axis inertia (J) are known a starting R_DGain setting may be calculated as follows:

   $R\_DGain = \dfrac{4000 \bullet \pi^2 \bullet J \bullet F_{cv}}{M\_StallTorq}$, using the M_StallTorq value displayed on the control panel.

   If not, set R_DGain = 10.

10) Press POWER ON. Verify that the SAM Drive status indicator displays [1] continuously. If not, a fault/error condition exists which must be eliminated before proceeding.

Before proceeding to next steps, make sure that the motor may move enough in both directions without any danger neither for humans nor for the machine.

---

11) Click on REL_MOVE to produce a short movement of the axis motor. If the motor goes into oscillation, or produces an unacceptable level of audible noise before during or following the movement, reduce the R_DGain setting by 25%. If there is no oscillation or unacceptable audio noise, increase the R_DGain setting by 100%.
12) Repeat step 10 until the highest setting of R_DGain without oscillation or unacceptable audible noise is found.

Be continuously aware that the motor is moving, and its load may thus hit machine limits

---

13) Click on POWER OFF, then POWER ON to reset position lag to zero.
14) Calculate a starting value of R_PGain as follows:

$$R\_PGain = R\_DGain^2 \bullet \frac{M\_StallTorq}{J} \bullet \frac{10^{-6}}{\pi},$$

where J is the axis total inertia. For M_StallTorq, use the value displayed on the control panel.

If axis inertia is unknown, set R_PGain = R_DGain. If the axis goes into oscillation, reduce R_PGain by 50%. If oscillation persists, reduce R_PGain by increments of 50% until oscillation stops.

15) If the Trace Control panel (see Figure 6, page 22) is not visible on the monitor, press  on the SAM Tools toolbar to bring in back into the foreground.
16) On the Trace Control panel press START to initiate a trace operation.
17) On the TUNING control panel, momentarily click and release TORQUE STEP to inject a torque disturbance and trigger the trace. Press UPLOAD on the Trace Control panel when the button becomes active to upload the trace to the monitor. The upload operation requires several seconds.
18) On the uploaded trace, note the general shape of POS_LAG at the positive transition point of TORQ_FLOW. The objective is to find the best setting of R_PGain for minimal overshoot and shortest settling time. Referring to the waveforms in Figure 25, increase or decrease R_PGain and repeat steps 14 through 17 until a satisfactory critically damped response is obtained. Use large increments of R-PGain (50% or so) initially until the upper and lower boundaries of a critically damped response are found, then smaller increments

until the best overall R_PGain setting is obtained. The trace zoom feature may be used to expand the area of interest.

SAM Tools automatically scale the vertical axis of each trace such that the display fills the available space. When comparing data from successive traces, be sure to note also the vertical axis scaling used.

On the uploaded traces, 180 units of POS_LAG represent approximately 1 degree of position lag, as measured at the motor shaft.

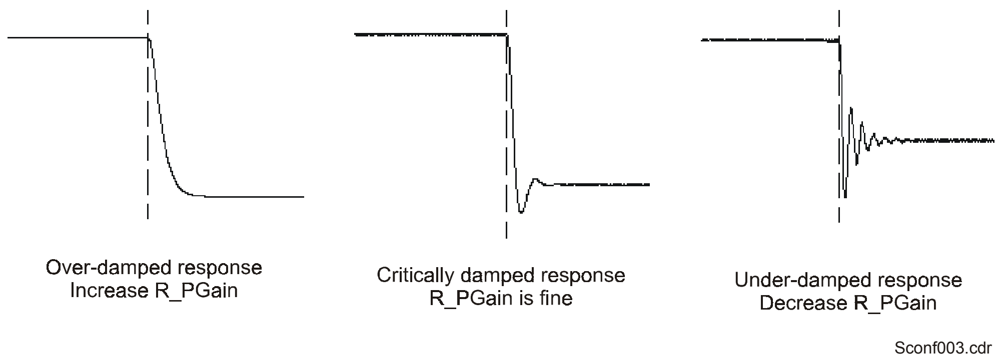


Figure 25 Reference Waveforms for Proportional plus Derivative Tuning Step 17.

If adjusting the Controller for PID mode operation: Jump to step 1 of next section.

---

19) Set the Feed-forward compensation (see Feed-forward Compensation on page 49).
20) Restore original value of the least significant digit of S_MStop0_AB recorded in step 5)
21) In the Ri_RegMode entry box, select “REG_MODE_PDPOS”.

Upon completion of this procedure, only the tuning parameters in RAM memory have been revised. The tuning parameter values in flash memory remain unchanged. Parameter values in RAM memory are lost upon power-down or resetting of the SAM Drive.

To permanently save the tuning parameters (as well as all other parameters) in flash memory, press the “SAVE PARAMETERS button on the Tuning control panel. To create a file copy of the SAM Drive parameters see “Uploading Parameters” on page 14.

PID Controller Adjustment Procedure

This paragraph presents the step by step procedure for tuning any SAM Drive whose Position Controller is to be configured to operate in PID (Proportional plus Integral plus Derivative) mode.

Keep in mind that using the SAM Feed-forward compensation provides a better accuracy than adding an integral part to the PD controller, when the goal is to follow a “tricky” trajectory (i.e. pick-and-place, cam-profile) AND when load disturbances are relatively small (i.e. 20% of motor rated torque).

The first part of this procedure is identical to the procedure for tuning a proportional plus derivative axis.

1) Perform step 1 through step 18 of the “PD Controller Adjustment Procedure” tuning procedure on page 43.
2) In the Ri_RegMode dialog box, select “REG_MODE_PIDPOS”.
3) If the axis inertia (J) is known a starting value of R_IGain may be calculated using the following relationship:

$$R\_IGain = \frac{4}{1000 \bullet \sqrt{\pi}} \bullet R\_PGain^{1.5} \bullet \sqrt{\frac{M\_StallTorq}{J}}$$

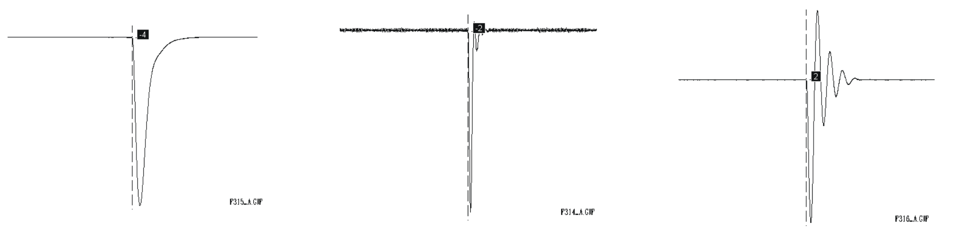
   For M_StallTorq, use the value displayed on the control panel.

   If R_IGain cannot be calculated, set:

$$R\_IGain = \frac{R\_PGain}{3}$$

4) If the Trace Control panel is not visible on the monitor, press on the SAM Tools toolbar to bring in back into the foreground. Press START to initiate a trace operation.
5) On the Tuning Control Panel, momentarily click and release TORQUE STEP to inject a torque disturbance and trigger the trace. Press UPLOAD on the Trace Control window when the button becomes active to upload the trace to the monitor.

6) On the uploaded trace, note the general shape of POS_LAG at the transition points of TORQFLOW. The objective is to find the setting of R_IGain which reduces POS_LAG to zero in the shortest time without increasing over-shoot. Referring to the waveforms in Figure 26, increase or decrease R_IGain and repeat steps 4 through 6 until a satisfactory critically damped response is obtained. Use large increments of R_IGain (50% or so) initially until the upper and lower boundaries of a critically damped response are found, then smaller increments until the best overall R_IGain setting is found. The trace zoom feature may be used to expand the area of interest.



Over-damped response
increase R_IGain

Critically damped response
R_IGain is fine

Under-damped response
decrease R_IGain

Sconf007.cdr

Figure 26 Example waveforms for Step 6.

7) Set the Feed-forward compensation (see Feed-forward Compensation on page 49).

8) Restore original value of the least significant digit of S_MStop0_AB recorded in step 5 of the Proportional plus Derivative tuning procedure.

9) In the Ri_RegMode:Parameter Value list entry box, select "REG_MODE_PIDPOS".

STOP

Upon completion of this procedure, <u>only</u> the tuning parameters in RAM memory have been revised. The tuning parameter values in flash memory remain <u>unchanged</u>. Parameter values in RAM memory are lost upon power-down or resetting of the SAM Drive.

To permanently save the tuning parameters (as well as all other parameters) in flash memory, press the "SAVE PARAMETERS button on the Tuning control panel. To create a file copy of the SAM Drive parameters see "Uploading Parameters" on page 14.

Feed-forward Compensation Adjustment Procedure

This procedure is applicable for PD and PID controller modes only. The “Torque” and “Free” controller modes do not utilize feed-forward compensation. The general sequence for setting feed-forward compensation values is weight, “dry friction”, viscous friction then inertia.

1) Setup the trace titled “REGPOS.STC”, which is found in the Promotion “CMDS” subdirectory.
2) On the Tuning control panel, note the current value of R_IGain. If R_IGain is non-zero, record the value then temporarily set R_IGain = 0.

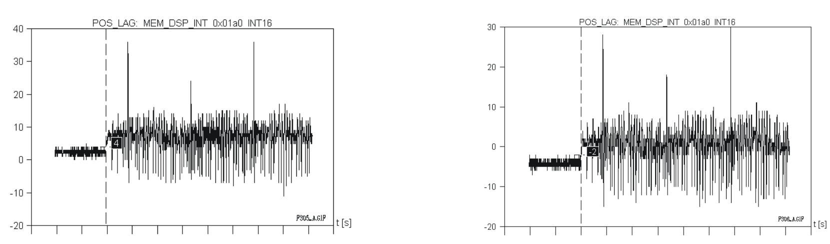
Adjusting the Weight compensation

3) If the axis weight (or constant force, i.e. produced by a spring) is known, enter the value (in mNm) in the **R_EXTTORQ** numeric entry box.

   If weight is unknown, read the value of field **RF_TORQQUIET**. As the motor is stopped while the SAM power stage is on and the SAM PD (or PID) controller has been previously tuned, the produced torque fits mainly to weight. Enter then this value in the **R_EXTTORQ** numeric entry box

Adjusting the “Dry friction” compensation

4) If the axis static friction torque is known, enter the value (in mNm) in the **R_STATFRICTORQ** numeric entry box. If static friction is unknown, enter zero.
5) Setup the control panel for a slow speed move (i.e. Travel_Speed = 360, Acceleration & Deceleration = 3600, Rel_Move [deg] = 720).
6) On the Trace Control panel, press START to initiate a trace operation.
7) Click on REL_MOVE to initiate an axis movement. Press UPLOAD on the Trace Control panel when the button becomes active to upload the trace to the monitor.
8) On the uploaded trace, estimate by eye the average value of **POSI_LAG**. Adjust **R_STATFRICTORQ** then repeat steps 6 and 7 until average **POS_LAG** is approximately zero (See Figure 27). If **POSI_LAG** is > 0, increasing **R_STATFRICTORQ** drives position lag in the negative (downward) direction.



Average position lag with no **R_VISCFRICTORQ** compensation

With correct **R_VISCFRICTORQ** compensation, average position lag during motion is ~0 (Watch the difference in vertical scales, as it is automatically adjusted to the measure range)

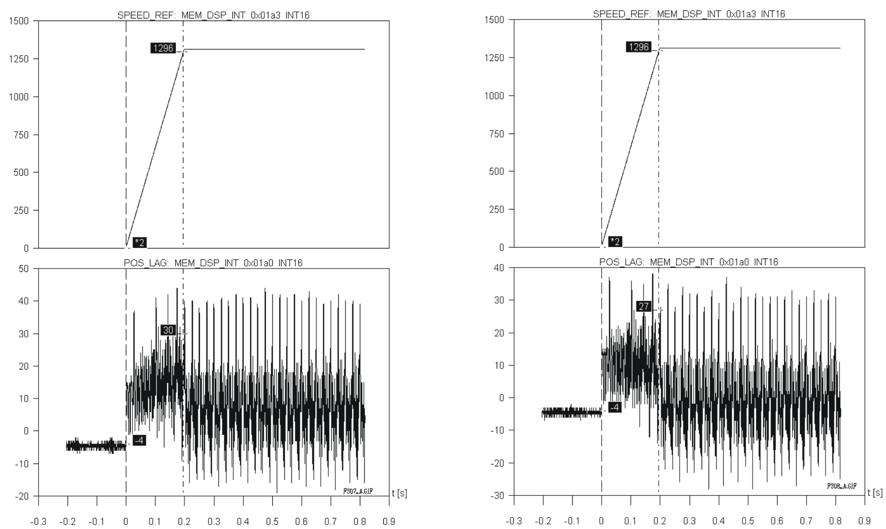
Sconf008.cdr

Figure 27 Static friction compensation examples for step 8.

Adjusting the Viscous friction compensation

9) Setup the control panel for a medium speed move (i.e. Travel_Speed = 7200, Acceleration & Deceleration = 36000, Rel_Move = 7200).
10) If the axis viscous friction torque is known, enter the value (in mNmS/100 Rad.) as **R_VISCFRICTORQ**.

    If viscous friction is unknown, enter zero.
11) On the Trace Control window, press START to initiate a trace operation.
12) Click on REL_MOVE to initiate an axis movement. Press UPLOAD on the Trace Control window when the button becomes active to upload the trace to the monitor.
13) On the uploaded trace, estimate by eye the average value of **POSI_LAG** during the constant speed portion of the motion. Adjust **R_VISCFRICTORQ** then repeat steps 11 and 12 until average **POSITION LAG** is approximately zero during the constant speed portion of the movement. If **POS_LAG** is > 0, increasing **R_VISCFRICTORQ** drives position lag in the negative (downward) direction.



Position lag with no **R_VISCFRICTORQ** compensation

With correct **R_VISCFRICTORQ** compensation, average position lag during constant speed is nearly 0.
(Watch the difference in vertical scales, as it is automatically adjusted to the measure range.)

Sconf009.cdr

Figure 28 Viscous friction compensation examples for step 13

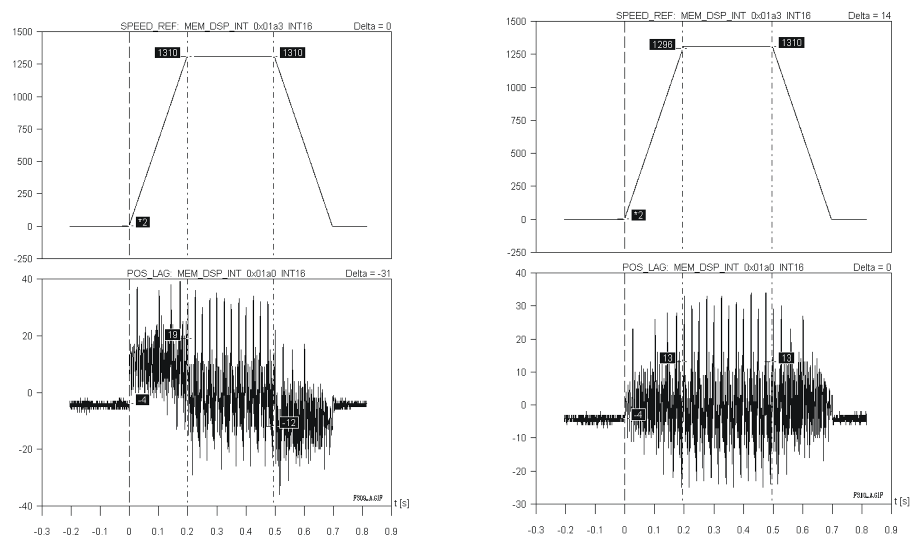
Adjusting the Inertia compensation

14) If the axis inertia is known, enter the value (in 10^{-6} Km^2) as **R_INERTIA.**

    If inertia is unknown, enter zero. Set Rel_Move = 3600.
15) On the Trace Control window, press START to initiate a trace operation.

16) Click on REL_MOVE to initiate an axis movement. Press UPLOAD on the Trace Control window when the button becomes active to upload the trace to the monitor.

17) On the uploaded trace, estimate by eye the average value of **POSI_LAG** during the acceleration and deceleration portions of the motion. Adjust **R_INERTIA** then repeat steps 15 and 16 until **POS_LAG** is approximately zero during the acceleration and deceleration portions of the movement. If **POS_LAG** is > 0, increasing **R_INERTIA** drives position lag in the negative (downward) direction.



Position lag with no **R_INERTIA** compensation

With correct **R_INERTIA** compensation, average position lag during constant speed is nearly 0.
(Watch the difference in vertical scales, as it is automatically adjusted to the measure range.)

Sconf010.cdr

Figure 29 Inertia compensation examples for Step 17

18) Repeating the whole procedure may enhance the precision of all feed-forward compensation. Then use other Travel_Speed, Acceleration and Deceleration settings, such as near the highest normal running speed, acceleration and decelerations to be used in actual operation.

19) Restore the value of R_IGain recorded in step 2.

Torque Mode Adjustments

1) In the Ri_RegMode list entry box, select “REG_MODE_TORQUE”.

In this mode the Position Controller is totally inactive, and torque commands are supplied by an external source.

Free Mode Adjustments

1) In the Ri_RegMode list entry box, select “REG_MODE_FREE”.

In this mode the Position Controller is totally inactive, and torque commands are supplied by an external source.

Emergency STOP Functions

Overview

i

For additional information on "safe" drive functions and machine level safety and protective functions, refer to the “PAM and SAM System User’s Handbook, Part 3 - Safety and Protective Functions".

Error Response

Dedicated hardware in conjunction with extensive monitoring by the SAM Drive firmware detect and respond to error/fault conditions occurring within the drive. Four fault/error response levels are defined:

STOP 0	immediate deactivation of the drive Power Stage
STOP 1	controlled stop (constant deceleration ramp) followed by Power Stage deactivation after a delay
STOP 2	controlled stop (as in STOP 1) but no Power Stage deactivation
USER SIGNAL	additional controlled stop (similar to STOP 2) for non error/fault conditions (as defined by the application)

STOP 0, STOP 1, STOP 2 and USER SIGNAL conditions are treated as “events” by PAM and SAM which means their occurrence initiates a defined response at the application program level. They are represented in the SAM Status and produce an indication on the Front Panel Status Indicator.

An application program can define how a SAM Drive responds to error/fault conditions (i.e. STOP 0, STOP 1 or STOP 2 response). The responses to certain critical fault/error conditions are defined by firmware (forced response) and not user-alterable or maskable.

User Safety Inputs

On every SAM Drive discrete user safety inputs (**USER STOP 0** and **USER STOP 1**) are provided to permit a fault/error response to be initiated by external circuitry. **USER STOP 0** and **USER STOP 1** are isolated 24 VDC PLC type user inputs. They provide sufficient redundancy to satisfy the criteria for category III safe standstill (per standard EN954-1).

Fatal Error Output

FATAL ERROR is a SAM Drive output (isolated relay contact) which is closed whenever no fatal error condition exists, or when the internal voltage supplies are not available. The **FATAL ERROR** contact normally controls current to a contactor supplying AC power to the SAM system. Upon occurrence of a fatal error, the **FATAL ERROR** contact opens, removing AC power from the SAM system.

Brake Output Option

The Brake Option is used for controlling an electromechanical brake on a motor equipped with this option. The output is on (conducting) when the power stage is enabled; it is off (not conducting) when the power stage is disabled. As an alternative the Brake Option can also be used for controlling a relay, which short-circuits the motor for quick stopping.

Status and Display

For each SAM System software version, the detailed list of Front Display codes and Status Bits is shown in ProMotion Help "SAM Status description" topic.

ProMotion Help "SAM Default action mask" topic shows the detailed default values of all status masks. Table 10 shows this list as an example.

MASK	AB HEX	STATUS_A 15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
			24 VDC low		junction over temperature	current regulator fault			stop 0 input active	DC bus overvoltage	power transistor saturation fault	15 VDC supply low	DSP cycle duration beyond limit	DSP Ram Check error		Power stage OFF	No secondary CPU (DSP) acknowledge
STOP0	0x59F9F401		X		X	X			X	X	X	X	X	X			X
STOP1	0x000000DC																
STOP2	0x00000000																
USER	0x00000000																

MASK	AB HEX	STATUS_B 15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
		High resolution resolver : measure defect	Low resolution resolver : measure defect	Encoder : measure defect	Magnetic angle not valid	Warning : High res. resolver meas. not good (nois	Brake option error	24 volt supply under warning limit	Aux sensor speed lag greather than limit	Motor thermal protection input active	Motor temperature greater than limit	Motor temperature > warning limit	Cooler temperature > warning limit	Ambient temperature greater than limit	Remote sensor error		Position lag greater than limit
STOP0	0x59F9F401	X	X	X	X		X										X
STOP1	0x000000DC									X	X		X	X	X		
STOP2	0x00000000																
USER	0x00000000																

MASK	CD HEX	STATUS_C 15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
		Host link transmission failure (hardware)	Host link disabled on corrupted frame	Host link disabled on time-out	Timeout waiting PAM synchronization	Host link communication RESET executed	Invalid host command data received	host cmd not executable due to the current state	Invalid host command code received	STOP1 input active	ref. speed not zero at power on	Option IO : outputs error	Option IO : 24 volt low	Stop0 on stop1 time-out	Application cycle duration beyond period	Main CPU cycle duration beyond limit	Main CPU fault (fault handler)
STOP0	0x004B2583										X			X		X	X
STOP1	0xF7800040	X	X	X	X		X	X	X	X							
STOP2	0x00000020																
USER	0x00040000														X		

MASK	CD HEX	STATUS_D 15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
		Error reported		Motor parameters are not valid	Parametre write protected	Parametre given value out of range	Parametres value not accepted	Default value used for other parameters (warnin	Drives parameters are not valid	Stop 0 ordered	Stop 1 ordered	Stop 2 ordered	Out of position limits	Out of speed limits	Trace triggered (reserved for test purpose)	Ram Check error	Firmware corrupted
STOP0	0x004B2583			X			X		X	X						X	X
STOP1	0xF7800040										X						
STOP2	0x00000020											X					
USER	0x00040000																

Table 10 SAM Default action mask (valid only for System 2.0_2)

STOP 0

Activation

The STOP 0 error response (see Figure 30) can be activated by conditions internal and external to the SAM Drive including:

- **USER STOP 0** input is set to low state
- STOP0 command from the PAM or from SAM Tools (via the service port)
- STOP0 command from an application (sequence) running in the SAM Drive
- A status condition pre-defined by Drive firmware (STOP0 Forced Mask) to initiate a STOP 0 becomes true
- A status condition pre-defined by the application (STOP0 Action Mask) to initiate a STOP 0 becomes true

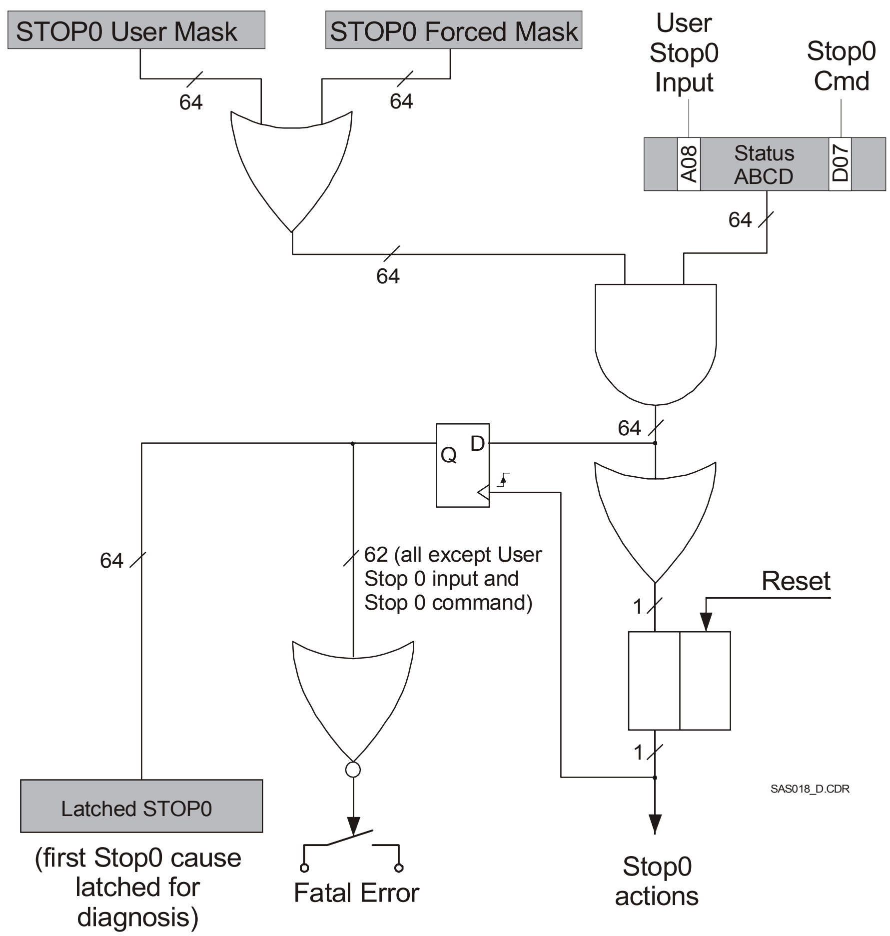


Figure 30 STOP0 Activation

Execution

STOP0 causes the following actions (see Figure 31) within the affected axis:

- output transistors of power stage are disabled, removing drive current to the axis motor
- Brake Control (Option) turns off current flow to motor brake
- The STOP0 EXECUTED status bit in SAM Drive Main Status is set
- Speed reference (internal TMP) is decreased to zero
- The STOP2 EXECUTED status bit in SAM Drive Main Status is set
- If the STOP 0 was activated internally by the SAM Drive firmware due to an error condition, the **FATAL ERROR** contact opens

---

A STOP0 due to activation of the **USER STOP 0** *input or a STOP0 command from the PAM or SAM Tools or from an internal sequence does not open the* **FATAL ERROR** *contact.*

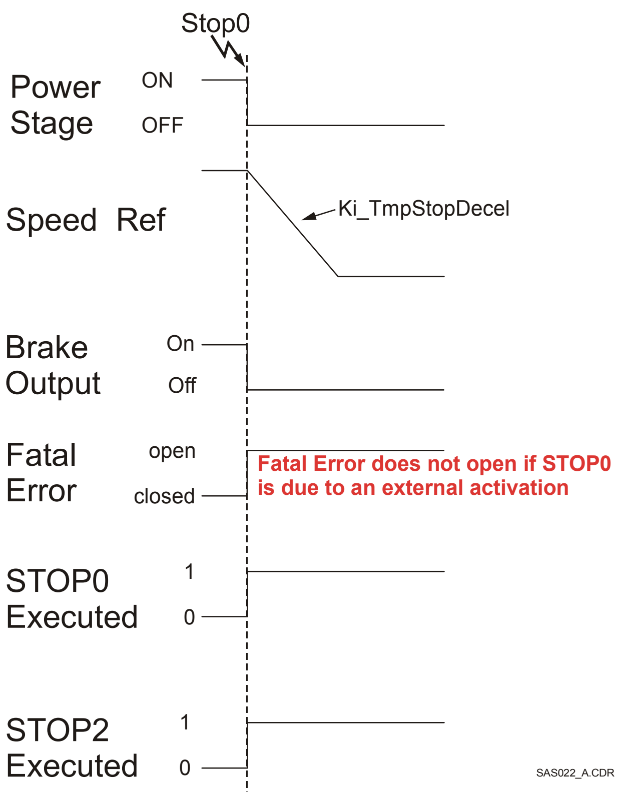


Figure 31 STOP0 Execution

STOP 1

Activation

A STOP1 error response (see Figure 32) can be activated by conditions internal and external to the SAM Drive including:

- **USER STOP 1** input is set to low state
- STOP1 command from the PAM or from SAM Tools (via the service port)
- A status condition pre-defined by Drive firmware (STOP1 Forced Mask) to initiate a STOP1 becomes true
- A status condition pre-defined by the application (STOP1 Action Mask) to initiate a STOP1 becomes true
- STOP1 command from an application (Sequence) running in the SAM Drive

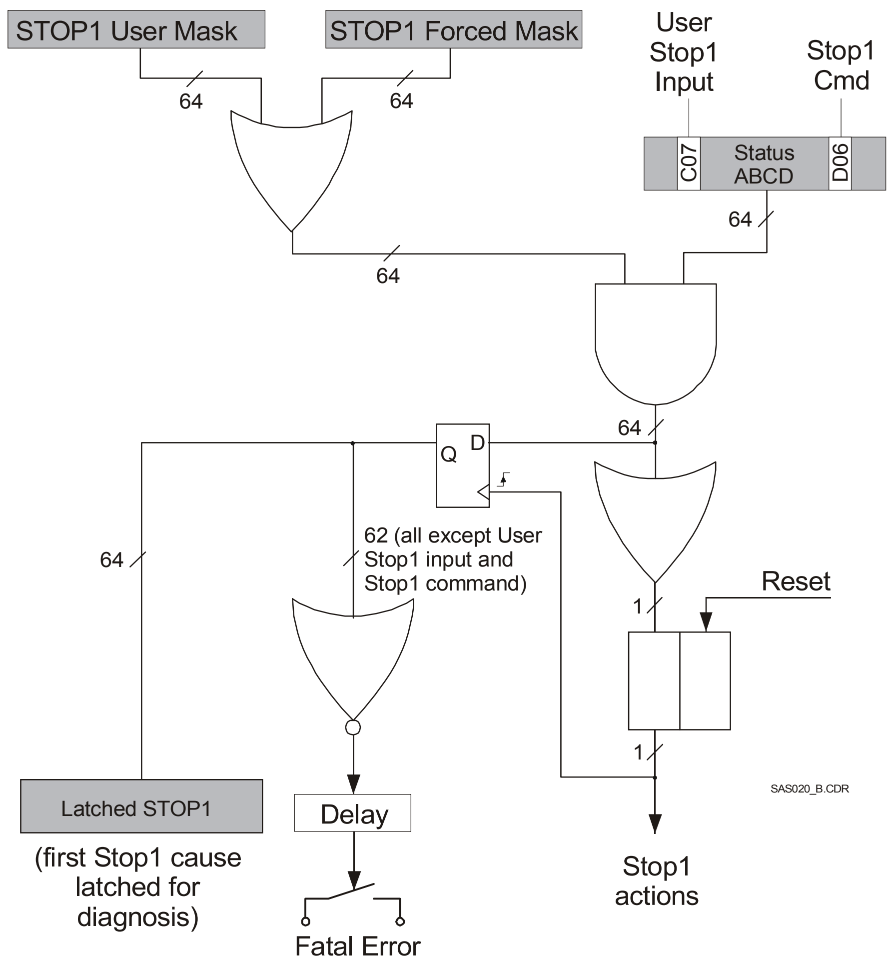


Figure 32 STOP1 Activation

Execution

STOP1 causes the following actions (See Figure 33) within the affected axis:

- Immediate Controlled Stop (axis decelerates to zero speed at a specified rate)
- The STOP1 EXECUTED status bit in SAM Main Status is set
- The STOP2 EXECUTED status bit in SAM Main Status is set

The following actions are taken following execution of the controlled stop:

- Output transistors of power stage are disabled, removing drive current to the axis motor
- Brake Control (Option) turns off current flow to motor brake
- If the STOP 1 was activated internally by the SAM Drive, the **FATAL ERROR** contact opens

A STOP1 due to activation of the **USER STOP 1** *Input or a STOP1 command from the PAM or SAM Tools or from an internal sequence <u>does not</u> open the* **FATAL ERROR** *contact.*

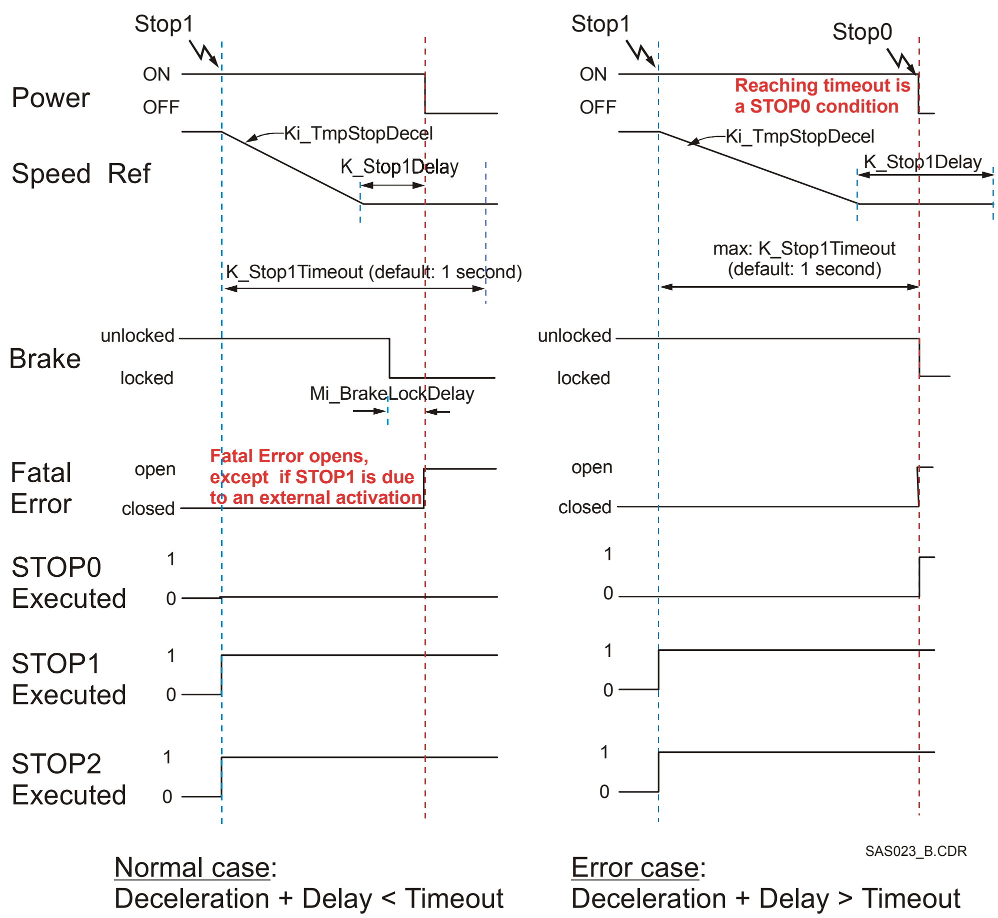


Figure 33 STOP1 Execution

STOP2

Activation

The STOP2 error response is similar to STOP1 except the Power Stage is not disabled and there is no external user input. STOP2 (see Figure 34) can be activated in the following ways:

- STOP2 command from the PAM or from SAM Tools (via the service port)
- A status condition pre-defined by Drive firmware (STOP2 Forced Mask) to initiate a STOP2 becomes true
- A status condition pre-defined by the application (STOP2 Action Mask) to initiate a STOP2 becomes true
- STOP2 command from an application (Sequence) running in the SAM Drive

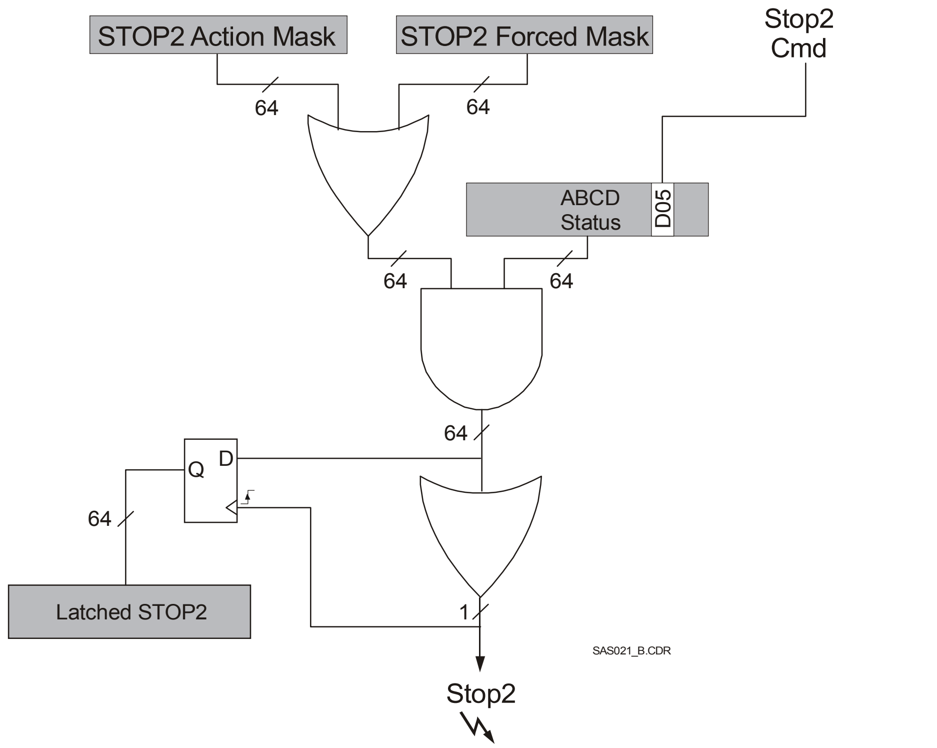


Figure 34 STOP2 Activation

Execution

STOP2 causes the following actions (see Figure 35) within the affected axis

- Axis decelerates to zero speed at a specified rate
- The STOP2 EXECUTED status bit in SAM Main Status is set

STOP2 does not affect the Power Stage, Brake Control or **FATAL ERROR** contact.

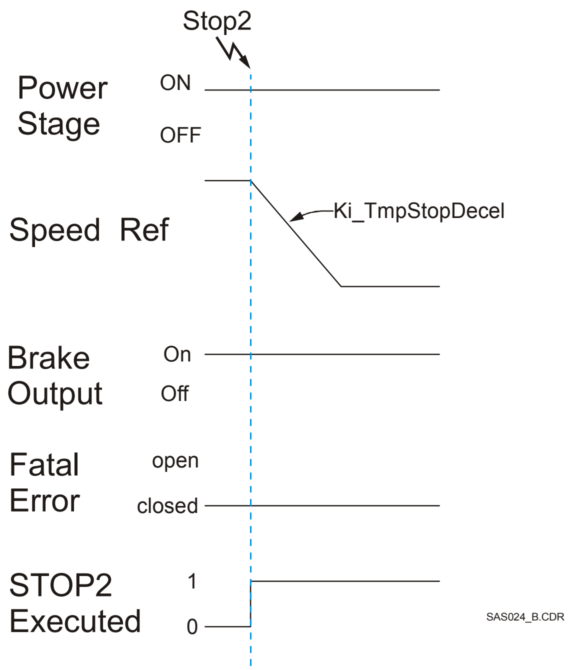


Figure 35 STOP2 Execution

USER SIGNAL

Activation

The USER SIGNAL error response is similar to STOP2 except that it does not influence directly the SAM Drive operation. It is used only for signaling to PAM (and/or to an internal sequence) that a faulty condition occurred, such as a motor temperature beyond “warning limit”, so that the machine can be slowed-down, or stopped in a controlled way. USER SIGNAL (see Figure 36) can be activated in the following ways:

- A status condition pre-defined by the application (USER SIGNAL Action Mask) to initiate a USER SIGNAL becomes true

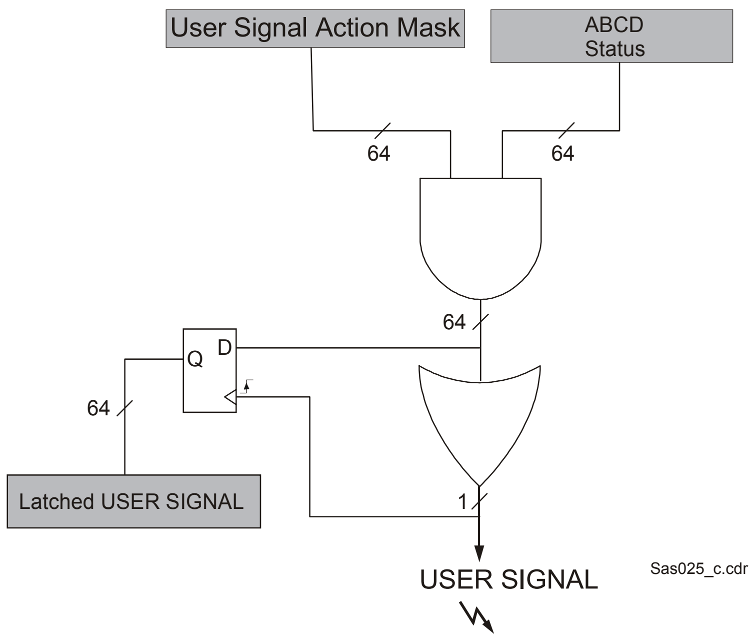


Figure 36 USER SIGNAL Activation

Execution

USER SIGNAL causes the following actions within the affected axis:

- The USER SIGNAL status bit in SAM Main Status is set

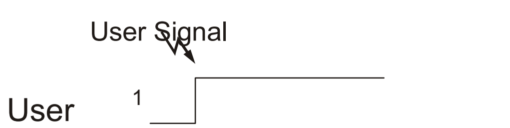


Figure 37 STOP2 Execution

STOP

A USER SIGNAL <u>does not open</u> the FATAL ERROR contact.

Fatal Error

FATAL ERROR is a SAM Drive output (isolated relay contact set) which is closed indicating no fatal error exists whenever all of the following conditions are satisfied:

- All internal supply voltages are okay (the DC Bus voltage is not considered an internal supply voltage)
- Initialization and internal checking sequences have been successfully completed
- Neither a STOP0 nor STOP1 internal error response has opened the **FATAL ERROR** relay

The **FATAL ERROR** output opens immediately upon occurrence of any of the following events:

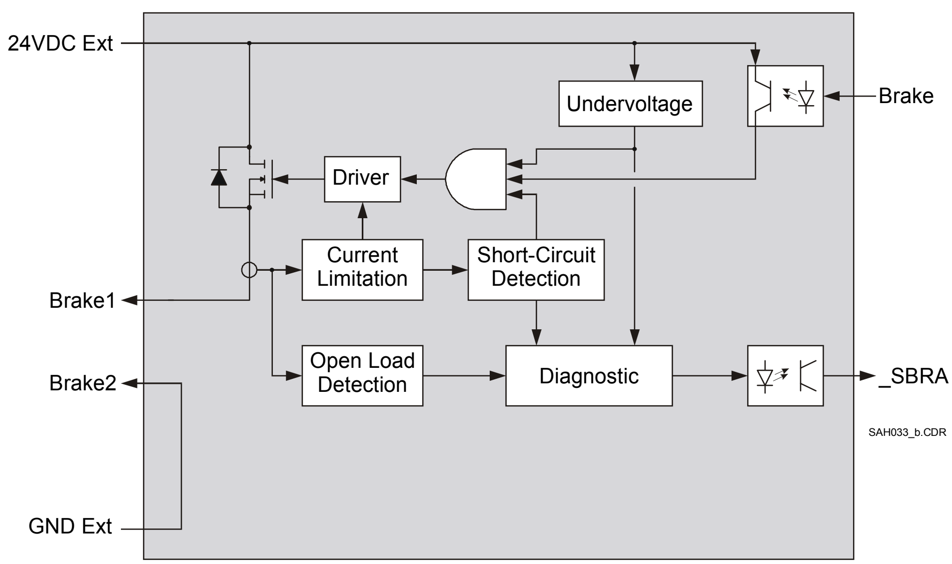
- Any internal voltage supply fails
- An internal SAM Drive STOP0 or STOP1 error response opens the **FATAL ERROR** contact

SAM Brake Option

Description

The SAM Brake Option is available on all SAM-DA-400-xxB-xxx-xxx. Only the lowest current rated SAM-DA-400-07N-xxx-xxx are not fitted with this option.

This Option is fitted with a solid-state output, which reacts to short-circuit, and also to open circuit (i.e. a brake wire gets broken). Such errors are signalized as "Brake error”.



•

Figure 38 Brake Option Functional Diagram

Brake handling (brake enabled)

Automatic handling

At power on the brake is unlocked when the power stage is acknowledged ON.

At power off and STOP0 the brake is simultaneously locked when the power stage is turned off (see section “STOP 0” on page 54).

During STOP1 execution, the brake is locked a few milliseconds before power off action. The delay is corresponding to the value of the field LOCK_DELAY, default value is 40 ms. In case of STOP1 time-out (occurring while speed does not fall quickly enough to zero) turn off of power stage and brake lock are applied simultaneously (see section “STOP 1” on page 56).

Manual handling

Lock and unlock method available from panel, when using SAM Tools.

Brake Object (class Cbrake)

Name	Type	Access	Units	Description
ENABLED	BOOL	RW		option situation
LOCK_STATE	BOOL	RO		ordered state of the brake
LOCK_DELAY	UNS16	RW	ms	delay before locking used by STOP1

Table 11 Brake Object fields

Refer to ProMotion Help “SAM Parameters and Fields access” Topic, and select “Brake fields for host”.

The field ENABLED is initialised to TRUE if:

- Ai_BrakeOptionInstalled = TRUE
  AND
- Mi_BrakeEnabled = TRUE

The field is modified from the PAM application according to the ENABLED value of the PAM brake declaration. Modification by panel is also possible.

Methods:

- lock lock of the brake (output is deactivated)
- unlock unlock of the brake (output is activated)

Parameters related to Brake Option

Name	Type	Units	Description
Ai_BrakeOptionInstalled	UNS16		0 = option not installed 1 = option installed
Mi_BrakeLockDelay	UNS16	ms	used to initialize LOCK_DELAY field default = 40 ms
Mi_BrakeEnabled	BOOL	ms	Indicate motor with brake default = TRUE

Table 12 Brake Object parameters

Refer to ProMotion Help “SAM Parameters and Fields" Topic, and select “System and motor parameters” for host access.

Brake behavior related to ENABLED field

Hardware Option availability	ENABLED	Behavior
not installed	FALSE	Error report disabled brake_lock = FALSE (logically)
not installed	TRUE	Brake error signaled brak_lock follow order (logically)
installed	FALSE	Error report disabled brake_lock = FALSE (logically)
installed	TRUE	Brake error signaled brak_lock follow order (logically)

Table 13 Brake Object behavior

Brake error

Bit 10 of status B indicates a brake error (refer to chapter “Status and Display” on page 53).

When set, the brake error bit of status B indicates any of following error conditions:

- short-circuit
- open load condition
- brake output transistor over-temperature

When the brake is enabled, but no hardware option is available (SAM-DA-400-xxN-xxx-xxx), the brake error bit is set. By default, when set, the brake error bit generates a STOP0 (see chapter “STOP 0” on page 53).

Checking SAM-to-Motor Wiring

Motor and Feedback Wiring Errors

Errors in the resolver feedback wiring and motor windings wiring between a motor and SAM Drive may produce erratic motion. This procedure provides a systematic method for isolating wiring errors between a Servomotor with standard single speed resolver and a SAM Drive.

Of the 720 possible ways to make resolver feedback connections to a SAM Drive, only one arrangement is correct. Of the remaining 719 incorrect configurations, most produce a Resolver A Measurement Error ([2] &[C] on the SAM Status indicator). A few incorrect resolver wiring configurations produce only erratic motion and - in some cases - an Excess Position Lag error ([2] & [y] on the SAM Status indicator). This procedure is for isolating the causes of erratic motion where no Resolver A Measurement Error is indicated.

The situation with motor winding connections is similar. Only one of the six possible arrangements is correct. The 5 incorrect wiring arrangements cause erratic motion and - in some cases - an Excess Position Lag error ([2] & [y] on the SAM Status indicator).

Incorrect motor or drive parameters can produce symptoms similar to those caused by motor or feedback wiring errors. Prior to performing this procedure, verify that the SAM Drive contains the correct motor and drive parameters (see {reference to downloading motor and drive parameters}) for the axis configuration.

This procedure utilizes the Control Panel "{control panel name}" which is a standard panel provided with SAM Tools.

Checking Procedure

When performing this procedure, the motor may run at any speed and in any direction. Prior to performing this procedure take measures necessary to prevent risk of damage to the driven equipment and injury to personnel.

The correct wiring is described in the "PAM and SAM System User's Manual, Part 2 – System Design and Integration". Refer to it whenever necessary.

step	procedure	normal response/indication	corrective action
1	In this procedure the motor shaft must be rotated by hand and it must turn freely. If necessary, uncouple the load from the motor.		
2	Connect SAM Drive on axis to be tested to service PC running SAM Tools	none	none
3	Apply 24 VDC power to SAM Drive.	After initialization SAM Drive status indicator displays [0] continuously	If SAM Drive status indicator displays other than [0] or displays [0] in sequence with other characters, other fault/error conditions exist which must be removed before proceeding with this procedure.
4	Activate the “resolver.pan” control panel.	none	
5	While manually turning the motor shaft in the clockwise direction (as viewed from in front of the motor mounting surface, looking toward the motor) and frequently refreshing the control panel display, monitor the value of POS_RES.	POS_RES increases as the motor shaft is rotated. At some point, POS-RES rolls over to a negative number and increases toward zero as the motor shaft is rotated.	If POS_RES decreases with clockwise rotation of the motor shaft, a wiring error exists in the connections between the motor-mounted resolver and connector X24 on the SAM Drive. Verify SAM Drive to resolver feedback wiring and correct any wiring errors or substitute a known good feedback cable and motor of the same type and model.
6	On the control panel: • select Regulation Mode = Reg_Mode_Free • Set PosReg:TORQ_FLOW = 1000 • Set CurReg:FREE_FREQ = 0. If SAM status indicator does not indicate [0], press “Reset STATUS” button. Press “Power ON” button. Goal is enabling SAM to produce a constant current vector locked on the angle CurReg:TETA.	SAM status indicator displays [1] indicating power stage is enabled. The motor shaft rotates to the closest position where it is in alignment with the current vector.	If SAM status indicator displays other than [1], other fault/error conditions exist which must be removed before proceeding.
7	Try turning the motor shaft by hand.	Magnetic flux produced by motor current from the SAM Drive creates an electrical détente, which prevents the motor shaft from turning freely. When rotated a few degrees in either direction and released, motor shaft returns to its original position.	If no resistance is felt, verify all motor windings connections from SAM Drive connector X12 to the motor windings connections Verify that DC Bus voltage is present at the SAM Drive.
8	On the control panel: • Set CurReg:FREE_FREQ = 10 SAM produces a current vector which rotates at a frequency of 1.2 Hz (approximately)	Motor shaft rotates slowly in the clockwise direction at constant speed: • ~36 RPM for 4 pole motors • ~24 RPM for 6 pole motors • ~18 RPM for 8 pole motors	If motor shaft rotation is counter-clockwise or the motion is erratic or there is no rotation, check for loose, broken or crossed connections from SAM Drive to motor windings connections

step	procedure	normal response/indication	corrective action
9	On the control panel: • Set CurReg:FREE_FREQ = 0	Motor shaft rotation stops	
10	On the control panel: • Set CurReg:TETA = -16384	Motor shaft rotates into stable position in alignment with current vector at constant angle designated by CurReg:TETA.	
11	On the control panel, refresh panel then read MainSensor:POS_RES.	POS_RES falls within one of the ranges of values listed in Table 15 for the motor type.	If POS_RES is outside one of the ranges of values listed in Table 15 by just a few degrees, increase PosReg:TORQ_FLOW to 2000. This provides additional current to overcome motor friction. If after increasing the value of TORQ_FLOW, POS_RES is still outside one of the ranges listed in Table 15, multiply the deviation by the number of pole pairs for the motor model (see Table 15). Then, if the result is close to 90 or 180, look for a wiring error in the resolver feedback interconnections. A result close to 120 strongly suggests a wiring error in the motor winding interconnections. Verify SAM Drive to motor interconnections or isolate the error by systematic substitution of known good feedback cable, motor windings cable and motor of the same model and type.
12	Restore the SAM Drive to its normal operating configuration by removing 24 VDC power. Wait a few seconds then re-apply power. The SAM drive restores the normal configuration saved in flash memory during initialization		

Table 14 Resolver Feedback and Motor Windings Wiring Verification Procedure

Servomotor type	**poles pole pairs**	**POS_RES range (for Table 14, step 11)**
AHD55x4 AHD70x4 AHR92x4	4 poles 2 pole pairs	0 ±1.0 ±180 ±1.0
AHR115x6 AHR142x6 ABMR190x6	6 poles 3 pole pairs	0 ±1.0 +120 ±1.0 -120 +±1.0
AHD190x8	8 poles 4 pole pairs	0 ±1.0 +90 ±1.0 ±180 ±1.0 -90 ±1.0
All BAUTZ Mxxx types	6 poles 3 pole pairs	0 ±1.0 +120 ±1.0 -120 +±1.0

Table 15 POS_RES Values for ACC AC Servomotors